POWER PLANT ENGINEERING

Established Over 29 Years

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Boilers in Straight Jackets

FOR MANY years the steam power plant has been on trial before a learned judge and a critical jury. The judge is "financial interest" and the jury a vast group of engineers who have insisted upon complete and truthful testimony. Boilers have been noted criminals, always stealing from the funds set aside for maintenance and operation. It is not surprising therefore to find that a recent decision of this high court has placed the boiler and its setting, not only behind the bars, but virtually in a straight jacket of steel framework.

On page 429 of this issue Walter M. Keenan tells of evidence which is being weighed and decisions which have been made.

SAMUEL BUTLER once wrote an interesting book in which he described a country where mechanical devices had reached such a stage of development that finally machines became the master and man the servant. In contemplating the many things which we are able to do by machines today it sometimes seems as if Butler's dream was not as fantastic as we thought it was. Consider, for instance, the action of the automatic synchronizer, described in the leading article of this issue. It does everything but think, in fact, we are not sure ourselves that it doesn't.

Marion Station Adds New Units

INDIANA GENERAL SERVICE CO. PLANT INSTALLS NEW TURBINE, BOILERS AND AUTOMATIC SYNCHRONIZER

TO ENABLE THE Marion, Ind., plant of the Indiana General Service Co. to meet the requirements of its increasing load, the plant has recently been enlarged by the addition of a 12,500-kv.a. Westinghouse turbo-generator and two 800-hp. B. & W. boilers, to operate at 200 lb. pressure. The total capacity of the plant is now 21,350 kv.a., with boilers rated at 3600 b.hp. Work on these additions was started in April, 1923, and finished in May, 1924.

This plant is located within the limits of the city of Marion, on the bank of the Mississinewa river. It carries the usual central station power and lighting load. Fluctuations in this load are not great and the load factor is good. A commercial heating load is also carried, using exhaust steam from the two vertical units. This heating load is a profitable one and materially improves the heat balance of the station.

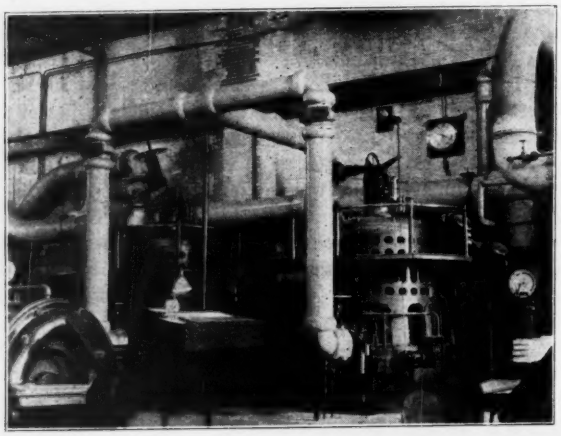


FIG. 1. TWO 500-KV.A. VERTICAL UNITS SUPPLY EXHAUST STEAM FOR HEATING LOAD

At the present time the plant contains one new 12,500-kv.a. Westinghouse horizontal turbo-generator, one 7850-kv.a. General Electric Co. horizontal turbo-generator and two 500-kv.a. General Electric vertical units. Former boiler equipment consisted of four 500-hp. B. & W. boilers, to which have been added two 800-hp. B. & W. boilers. In addition, the boiler house contains three 260-hp. Stirling waste heat boilers.

The plant, together with the coal storage space, occupies about 2½ acres. Brick and concrete construction is used for the main building, which is 225 ft. by 100 ft. The roofing is of slate composition and floors throughout are of reinforced concrete. Interior finish is white, for the most part. The building is well lighted and ventilated by steel-sash, wire-glass windows and doors. Swinging and hinged windows, as well as sky-lights, are usually kept partially open to insure good ventilation. Ivanhoe-Regent lights are used in the turbine room and there are 14 R. L. M. domes in the boiler room.

Indiana and Illinois screenings, with a heating value of 11,000 B.t.u. are burned at this plant. This fuel contains 14 per cent moisture, 14 per cent ash, 40.1 per cent fixed carbon and 31.3 per cent volatile. Upon the arrival of the coal, it is put into storage in the yard, which has a storage capacity of about 120,000 T. From the storage piles, it is taken by a grab bucket to a belt conveyor, which takes it into the boiler house. After passing from the belt conveyor to a Jeffrey coal crusher, which is motor-driven, it is weighed by a Merrick weightometer and then goes to a bucket elevator running the full length of the boiler room. This bucket elevator discharges the coal directly into the stoker hoppers, no coal bunkers being used inside

the boiler house. This coal conveyor system was supplied by the Stephens-Adamson Mfg. Co.

New Boilers Are Installed

Two new 800-hp. B. & W. boilers, of the straight tube type, with superheaters, similar to the four 500-hp. B. & W. boilers already installed, supply the increased steam demands of the station. Each of these new 800-hp. boilers has a heating surface of 8004 sq. ft., with an additional superheater surface of 1135 sq. ft. The normal evaporation is 6.8 lb. of water per lb. of coal, although at times it is higher, as shown on the test report, where it is 7.1 lb. per lb. of coal fired. The heating surface per kilowatt installed capacity is about 2.1 sq. ft. The superheat shown on the test is 139 deg. Details of these boilers, which operate at 200 lb. pressure, may be found in Fig. 5.

Three Stirling waste heat boilers of 260 hp. each, with a total heating surface of 7800 sq. ft., are also installed in the boiler house, and serve a double purpose. The first use of these boilers is as auxiliaries for supplying the commercial heating load carried by the Marion station. About 150,000 sq. ft. of radiating surface, installed in the business district of Marion, is supplied by the station. Most of this is supplied by the exhaust of the two 500-kv.a. vertical turbines aided by the steam from these boilers. In unusually cold weather, live steam is also turned into the system.

Heat for these Stirlings is supplied by the flue gases of the four 500-hp. boilers, at a temperature of about 550 deg. The flue gases from the new boilers are not used for this purpose, as it was necessary, when installing these boilers, to make a separate connection to the stack. During the summer months, the waste heat boilers will be used as economizers, heating the feed-water.

Boiler feed water is taken from the river, together with the condenser circulating water, through stationary screens. It is first treated by a special treatment process installed by the Dearborn Chemical Co. One open feed-water heater, supplied by the Cochrane Corp., serves all the boilers. The average temperature of the feed water entering the intake is about 60 deg. F., and it leaves the feed-water heater at an average temperature of 185 deg. F. under normal operating conditions.

Three boiler-feed pumps are employed, all steam driven, two of the pumps having a capacity of 750 g.p.m. and the third of 350 g.p.m. Feed water is controlled by six regulators, furnished by The "S-C" Regulator Mfg. Co.

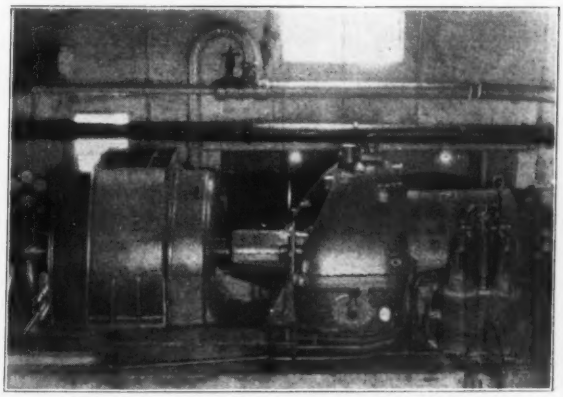


FIG. 2. NEW 12,500-KV.A. WESTINGHOUSE TURBO-GENERATOR, SHOWING GENERATOR VENTILATION

These six B. & W. boilers are set with M. H. Detrick Co., dutch ovens and Coxe type "C" chain grate stokers, the latter made by Combustion Engineering Corp. These grates are 16 ft. 4 in. long and 10 ft. 8 in. wide, giving a grate area of 175 sq. ft., the boilers being set with the lower row of tubes 16 ft. above the grates. These Coxe stokers are driven from the rear sprocket, through a lay shaft, by motors and engines located in the aisle behind the boilers. An average of 35 lb. of dry coal per sq. ft. of grate surface per hr. is burned on these stokers.

Ash from these furnaces drops into ash hoppers in the basement, from which it is taken by an open drag link conveyor running in front of the hoppers. This conveyor takes it outside to the yard ash-pile. The city of Marion uses all this ash for filling purposes and it is ultimately removed from the yard by truck.

Natural draft is used with the four-500-hp. boilers and both forced and induced draft with the two new 800-hp. units. Figure 5 shows the position of the fans with respect to the boilers and Fig. 3 gives a closer view of one of the fans with its driving motor. The damper controls are all hand-operated. One reinforced concrete chimney serves the whole boiler installation. This chimney is 150 ft. high and 12 ft. in diameter, thus giving a stack area of 2.86 sq. ft. per 1000 sq. ft. of boiler heating surface. Draft readings are taken from combination vertical and inclined tube draft gages, made by Lewis M. Ellison. Each of the six boilers has a complete equipment of these gages.

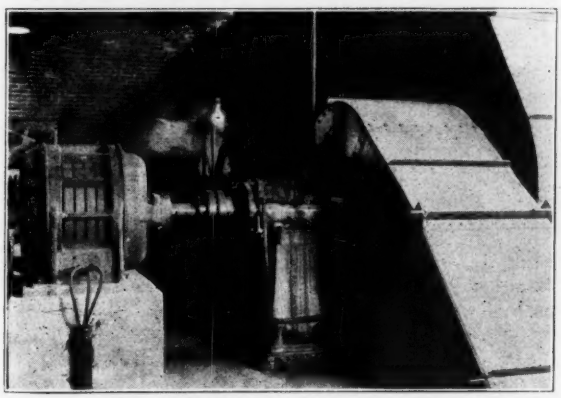


FIG. 3. INDUCED DRAFT FANS ON NEW BOILERS ARE MOTOR DRIVEN

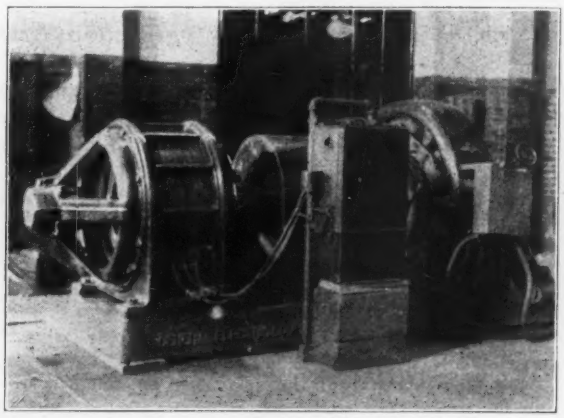


FIG. 4. ONE OF THE THREE MOTOR-GENERATOR SETS THAT FURNISH EXCITATION

Steam flow meters, supplied by General Electric Co., are installed on the two new boiler units. The outfit of indicating and recording thermometers and breeching pyrometers was supplied by the The Bristol Co. and Wilson-Maeulen Co.

Pipe covering of 85 per cent magnesia was furnished by Johns-Manville and The Philip Carey Co.

Soot blowers made by the Marion Machine & Foundry Co. are installed on all the boilers. These soot blowers are operated 3 times a day.

Full Equipment of Instruments Aids Operation

For determining flue gas composition on all the 500-hp. boilers, a Hayes hand Orsat is used. Each of the new units, however, is equipped with a continuous reading, recording type CO_2 meter mounted on the gage board. In addition, an electric CO_2 and CO recorder, made by the Bacharach Industrial Instrument Co., has been installed. Steam gages throughout the plant are furnished by the Ashton Valve Co. Everlasting blowoff valves, made by the Everlasting Valve Co., are installed on all boilers. Each 500-hp. unit has two of these blowoff valves, and each 800-hp. unit has three blowoff valves.

In the turbine room, which was rearranged to accommodate the new Westinghouse unit, the total power now available is 21,350 kv.a. The new 12,500 kv.a. Westinghouse unit has a guaranteed water rate of 12.5 lb. per kw-hr.

Exhaust steam from the two 500-kv.a. vertical units goes to the commercial heating system referred to above. During the period when heating steam is not required, these two vertical units exhaust into small Wheeler condensers. The new Westinghouse unit is equipped with a Westinghouse condenser.

Condenser circulating pumps are motor driven through reduction gears. Circulation water for these four condensers flows from the river through the screens and intake tunnel. The average temperature of this water is about 60 deg. F. The flow of the river is at all times ample to take care of the circulating water requirements and no special methods of cooling are employed. The discharge tunnel empties into the river at a point about 100 ft. downstream from the intake. Six Venturi meters, furnished by the Builders Iron Foundry, measure the water taken from the intake tunnel by the boilers. Four of these meters have a capacity of 70,000 lb. per hr. and two of 120,000 lb. per hr.

All generator units are wound for 3-phase, 60-cycle alternating current. Open ventilation is used on all units.

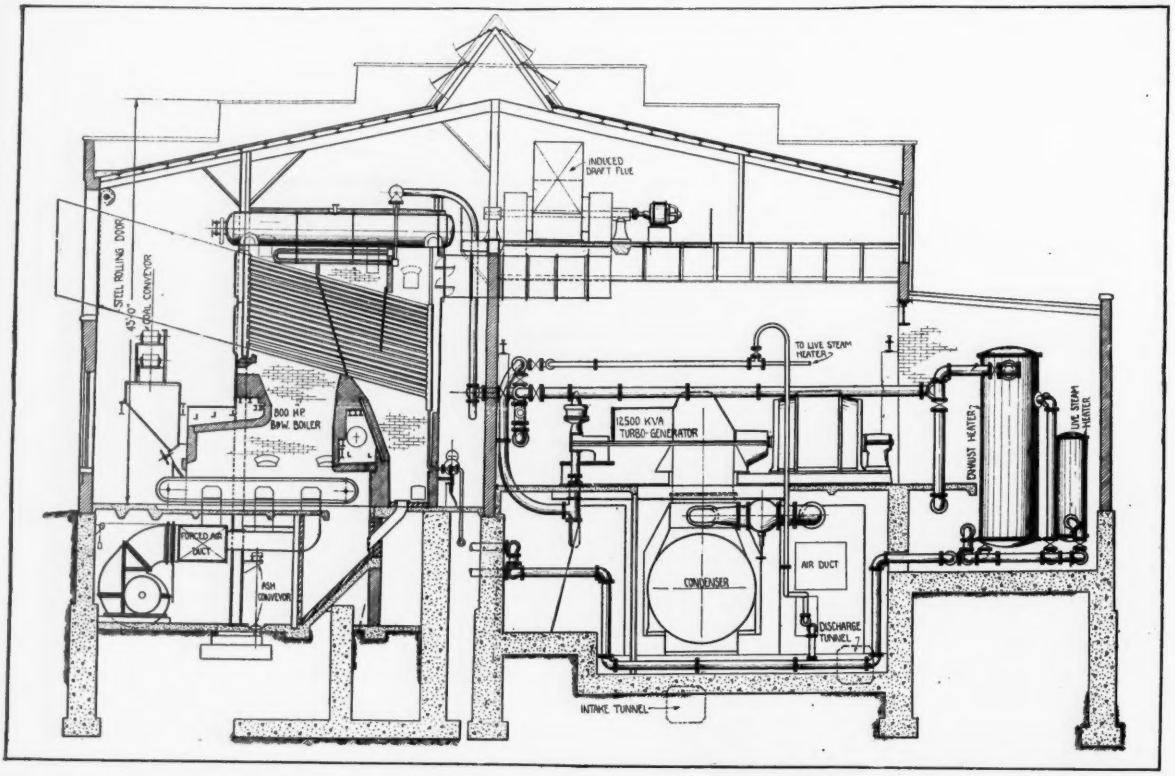


FIG. 5. BOILERS, 12,500-KV.A. UNIT AND HEATERS HAVE BEEN ARRANGED FOR CONVENIENCE OF OPERATION

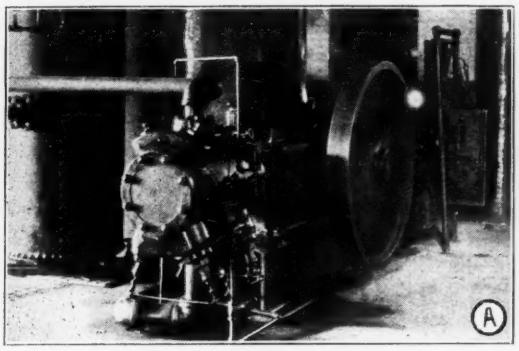
The oil for the new 12,500-kv.a. unit is cleaned by passing through a patent oil cleaner.

Motor-Generator Sets Supply Excitation

Excitation for all the units is supplied by three motor-driven exciters, located in the turbine room. If it is ever necessary to shut down, the excitation for starting can be taken from a 60-cell storage battery. This battery, supplied by the Electric Storage Battery Co., is ordinarily used to supply current for the various electrical control systems. For this purpose a suitable equipment of relays and automatic switches is used with the battery.

The switchboard of the Marion plant consists of 40 panels of soapstone and marble, with lacquered finish, 30 panels on the a.c. board and 10 on the d.c. board. These

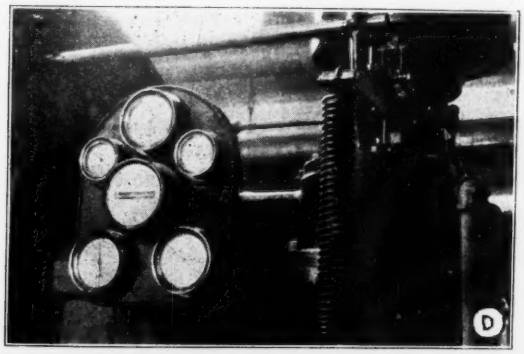
Fig. 6. Instruments and Miscellaneous Equipment Are Well Arranged



A—A small motor-driven air compressor, installed in the turbine room supplies air for construction work and other needs about the plant.

B—Drag link conveyor takes ash direct to the yard from the ash hoppers in the boiler house; it is removed by truck from the yard. This arrangement is simple and economical for the Marion plant.

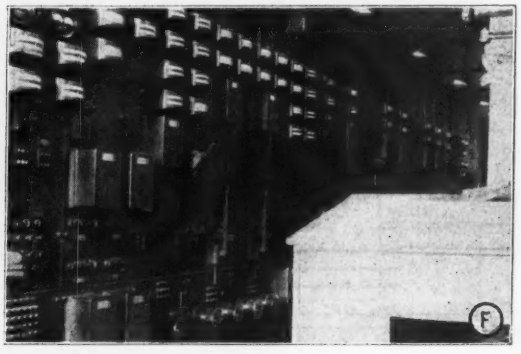
C—Each stoker is equipped with suitable wind-box controls, conveniently located at the front of the boiler as shown. In addition, a gage board on each boiler carries a draft gage connected so that readings can be taken at various parts of the setting, thus providing the fireman with all information necessary for burning coal in the most economical manner. Careful records are kept on the data sheets shown hanging beside the gage.



D—The gage board of the new 12,500-kv.a. unit is conveniently located near the governor and throttle valve, and bears all the gages necessary to give the operator full information at all times.

E—One end of the switchboard. The automatic synchronizer described above is shown on the panel at the extreme right of the figure, enclosed in a glass case. When this synchronizer is installed, it is adjusted to the particular characteristics of the generators with which it is to be used. It is designed to operate without attention on the part of the operator.

F—The remainder of the switchboard, showing an unusually complete equipment of meters. This board is also provided with signal systems, as well as control devices of various types, both hand-operated and automatic.



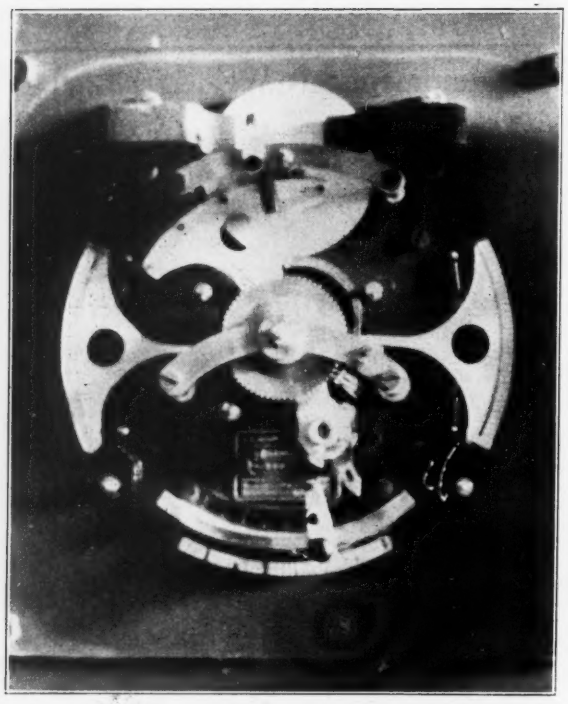


FIG. 7. BROWN-BOVERI AUTOMATIC SYNCHRONIZER, SHOWING TIME-LAG RELAY AND SECTORS OF REGULATING DEVICE

panels, made by General Electric Co., are supported on a frame work of iron pipe. Bus bars are 4 in. double bars for each phase. All cable is of 5000 v. capacity, braided and covered with varnished cambric. Bus bar and cable supports were supplied by the Electrical Engineers Equipment Co., the General Devices & Fittings Co., and the Delta-Star Electric Co. Miscellaneous inside equipment was furnished by the General Devices & Fittings Co. High voltage switching equipment, of General Electric Co. manufacture, has a capacity of 800 amp. For low voltage switching, General Electric Co. types K-5, K-3 and H-6 switches are used. All safety switches are of the automatic type.

For load bulletins and signal service, a complete light and bell system, furnished by General Electric Co., is installed. Station lighting current is taken from 110-v. transformers connected to the station bus bars, current from the storage battery being available for emergency use.

In accordance with the latest practice, the transformers with much of their auxiliary equipment are placed outside the station. This installation comprises three 1000-kv.a. air and oil-cooled transformers wound for 33,000/2300 v., and three 3000-kv.a. water and oil-cooled transformers for the same voltages. These are of General Electric Co. manufacture. The 1000-kv.a. units are the station service transformers, the 3000-kv.a. units for the main transmission lines. Fourteen protective reactors, of three and five per cent, are used; the distribution line reactors are rated at 1500 kv.a. and the high tension transmission line reactors at 6000 kv.a.

Brown-Boveri Automatic Synchronizer Is Used Successfully

All instruments on the plant switchboard are of General Electric Co. make, with the exception of the Brown-Boveri automatic synchronizer. This instrument is made by Brown-Boveri & Co. of Baden, Switzerland and, as its use is not common in this country, a brief description of it may be of interest here. The use of the automatic synchronizer, reported to be quite common in Europe, is comparatively a new development in American practice. Those who have used the Brown-Boveri instrument have obtained good results with it, finding that it puts the incoming machine on the line absolutely in phase, at the correct frequency and voltage and without the slightest shock. Figure 7 shows the construction of this synchronizer and Fig. 8 gives a wiring diagram of its connections.

In the same way as with synchronizing lamps, the automatic synchronizer is connected to the circuits of the two sets to be synchronized, as shown in Fig. 8. The apparatus includes two distinct devices: (a) the time-lag relay with a contact, which, when closed, actuates the remote control of the oil switch; (b) the regulating device, which imparts to the relay its characteristic.

In the time-lag relay, an aluminum disk (shown near the top of the instrument in Fig. 7) rotates under the influence of the rotating field produced by the two electromagnets m, Fig. 8. This disk winds up a thread, the end

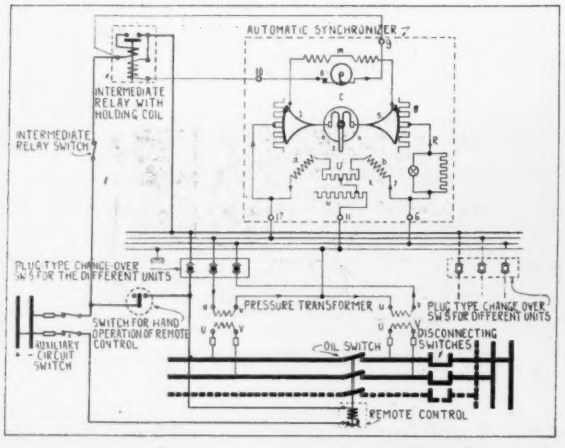

AUTOMATIC SYNCHRONIZER
INTERMEDIATE RELAY WITH HOLDING COIL
INTERMEDIATE RELAY SWITCH
PLUG TYPE CHANGE OVER SW'S FOR THE DIFFERENT UNITS
PRESSURE TRANSFORMER
PLUG TYPE CHANGE OVER SW'S FOR DIFFERENT UNITS
SWITCH FOR HAND OPERATION OF REMOTE CONTROL
AUXILIARY - CIRCUIT SWITCH
OIL SWITCH
DISCONNECTING SWITCHES
REMOTE CONTROL

FIG. 8. MOTION OF SECTORS S-S REGULATES CURRENT IN TIME-LAG RELAY OF AUTOMATIC SYNCHRONIZER

FIG. 9. TRANSFORMER EQUIPMENT IS INSTALLED OUTDOORS, ACCORDING TO LATEST PRACTICE

TABLE SHOWING DATA OBTAINED DURING 10-HR. RUN OF 800-HP. B. & W. BOILER

Indiana General Service Company			Coal Test Report		
Test on Ohio Mine Run Boilers #2			H.P. 800 Test No.		
Made at Marion Plant			Date of Test January 18, 1924.		
Test Conducted for Burning coal on Coxe Stokers			Water		
Duration	hrs.	10	Total used (By Venturi Meter)	lbs.	438991
Stack, material 150' height 12' dia.			Total evaporation into dry steam	lbs.	438991
Furnace, type Detrick Dutch Oven			Factor of evaporation including superheat		1.12
Furnace, height grate to tubes	ft.	16	Cor. For. Temp.		99.3
Grate, type Chain "C"			Total evaporation from and at 212° F.	lbs.	488309
Grate, length 16' 4" width 10' 8"	sq.ft.	175	Evaporation from and at 212° F. per hour	"	48830
Heating surface of boiler	"	8004	Evaporation per lb. (as fed)	lbs.	7.1
Heating surface of superheater	"	1135	Evaporation per lb. from and at 212° F.	"	7.96
Boiler Hours		10	Evaporation per lb. of combustible	"	7.59
Pressure			Evaporation per lb. combustible from and at 212° F.	"	8.5
Barometer	in.	29	Evaporation per sq. ft. of H.S. from and at 212° F.	"	
Steam gauge	lbs.	197	Horse Power		
1st pass	in.		Horse power developed A.S.M.E. standard	H.P.	1418
2nd pass	"		Per cent. of rating developed	%	177
3rd pass	"		Horse power per sq. ft. of Grate	H.P.	8.1
4th pass	"		Analysis		
Over fire	"	0.04	Flue Gas		
Stack	"	1.8	CO_2 O CO N^2		
Temperatures			11.2 -- --		
Outside air	°F	34	Coal		
Boiler room	"	70	M Vol.Matter Fixed Carbon Ash		
Feed water	"	139	Ash		
Steam	"	520	M Vol.Matter Fixed Carbon Ash		
Degrees of Superheat	"	139	Heat value of dry fuel per lb., calculated	B.T.U.	13500
Flue gases	"	568	Heat value of dry fuel per lb., by calorimeter	"	
Fuel			Heat value of combustible, per lb.	"	
Kind Ohio Mine Run			Heat value per lb., steam	"	
Total used	lbs.	61231	Efficiency		
Moisture added at time of test	%		Boiler and furnace	%	57.3
Total ash	lbs.	3918			
Ash, per cent. of fuel	%	6.39	Remarks: An average fire of 4-3/4 in. was maintained, keeping CO to a minimum. Induced draft fan became affected by high stack temperature.		
Combustible	lbs.	57413			
Dry fuel per hour per sq. ft. of grate	lbs.	35.			
Combustible per hour per sq. ft. of grate	"	32.8			
Cost per 1000 lbs. Equi water evaporated	c	.265			

of which is fastened to a contact attached to a spring, as at o. When the currents of the two machines to be paralleled are coming into step, current begins to flow through coils m, the disk begins to rotate and, just at the right moment, the thread is wound up and contact o closes. This completes the circuit through the intermediate relay, which operates the remote control and throws in the oil switch that connects the machines in parallel.

On account of the fact that the operation of the various relays takes a small amount of time, if the magnet coils m were fed direct from the circuits to be paralleled, synchronizing would not take place exactly at the moment when the currents through m are exactly in phase, therefore exchange currents would flow between the two machines; to eliminate this danger a regulating device is used.

Instead of feeding coils m direct, the regulating device causes the current to pass through regulating resistances g. Current through these resistances is controlled by the rotation of sectors s, bearing contacts that throw sections of the coils into the circuit. This rotation of the sectors is brought about by a rotating field produced by a and b, acting on a rotating drum c, Fig. 9. If the two circuits to be paralleled are exactly in phase, the drum is in equilibrium in the mean position and resistances g are short-circuited, putting the time-lag relay directly under the control of the two circuit.

When the circuits are not in phase, the sectors will be rotated a small amount, resistance will be thrown in and the current through coils m will be weak, except as phase coincidence is approached, when the current in coils m builds up rapidly, the relay disk winds up the thread quickly and contact o closes, thus throwing the incoming unit into circuit just at the point of synchronism.

Proper adjustments of the various coils and limit stops of the regulating device are made, when the instrument is installed, to suit the wave shape of the alternators and other conditions of the circuits. By making these adjustments, proper allowance can be made for the time necessary for intermediate and remote control relays to throw in, so during the extremely short period when the currents of the two machines are coming into phase, in what is called the interference period, the oil switch makes contact exactly at the point of synchronization.

Data taken during a 10-hr. run from one of the new 800-hp. boilers, on January 18, 1924, are shown in the accompanying table. Ohio mine run coal, with a calculated heat value of 13,500 B.t.u. per lb. dry fuel, was

mesh. With anthracite, however, containing less than 5 per cent volatile, it is necessary to pulverize finer, and satburned on the Coxe stokers during this test. An average thickness of fire of 4¾ in. was maintained, keeping CO to a minimum, and giving 11.2 per cent CO_2. Draft was 0.04 in. over the fire and 1.8 in. in the stack. Flue gas temperatures were somewhat high, averaging 568 deg., and affecting the induced draft fan. Feed water was taken into the boiler at 139 deg., and steam was generated at 197 lb. gage pressure and 139 deg. F. superheat. The evaporation per lb. of coal fired was 7.1 lb. and the equivalent evaporation 7.96, while 7.59 lb. of water were evaporated per lb. of combustible. On this run, the boiler operated at 177 per cent rating, developing 1418 b.hp. The efficiency of boiler and furnace was 57.3 per cent.

This plant at Marion forms part of the system owned and operated by the American Gas and Electric Co. of New York; the engineering and construction departments of this company designed and built the plant. Data and photographs used in this description were obtained through the courtesy of H. M. Kemmer, efficiency engineer of the plant.

Drying of Coal for Pulverizing

POINTS TO BE CONSIDERED WHEN DECIDING WHETHER OR NOT TO USE DRIERS. BY H. W. BROOKS

PROBABLY the two most discussed problems connected with pulverized fuel firing are those of combustion volume and drying. The solution of the former is somewhat complicated and, while promising commercial scale

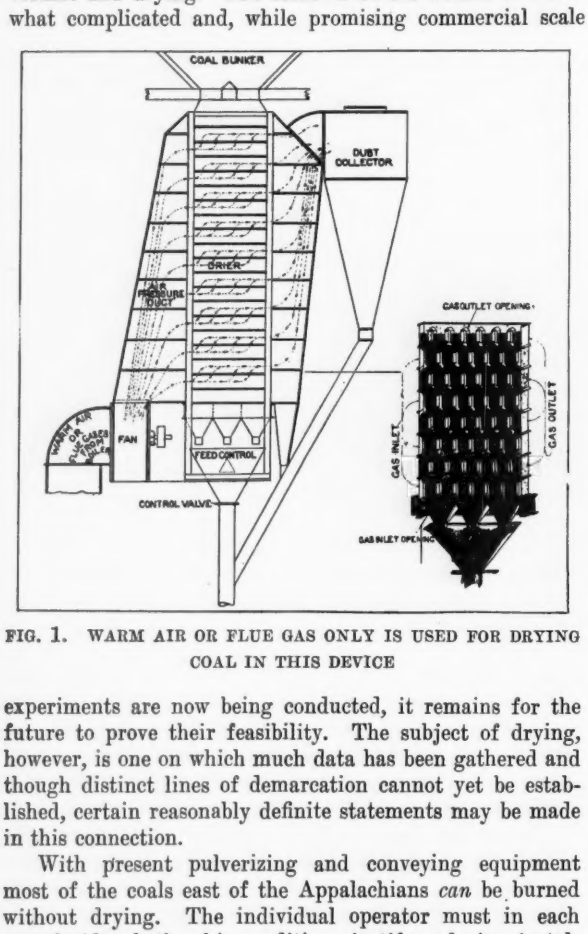


FIG. 1. WARM AIR OR FLUE GAS ONLY IS USED FOR DRYING COAL IN THIS DEVICE

experiments are now being conducted, it remains for the future to prove their feasibility. The subject of drying, however, is one on which much data has been gathered and though distinct lines of demarcation cannot yet be established, certain reasonably definite statements may be made in this connection.

With present pulverizing and conveying equipment most of the coals east of the Appalachians *can* be burned without drying. The individual operator must in each case decide whether his conditions justify a drying installation or not. Undried coal decreases evaporation in the furnace. Damp pulverized coal is expensive to grind and hard to transport. The absence of drying equipment may cause trouble during an emergency, for which reason it is frequently good business insurance to install driers even where these eastern coals are burned.

Illinois coals all require drying equipment for successful operation. Texas, Colorado and North Dakota lignites should all be dried. In general, no difficulty is experienced with coal that carries one or two per cent of free or surface moisture in addition to inherent moisture if this coal is not heated over 12 deg. F. Under such condition the pulverizer will operate at full capacity. This means that a Pittsburgh coal may carry two to three per cent total moisture, a Franklin County, Illinois, coal 5 to 6 per cent, and Carbon County, Montana, coal 7 to 8 per cent. All of these coals will appear to the eye equally dry. In fact, with greater surface moisture they still may appear dry to the eye but if they are carrying a temperature of say 200 deg. F., they will give off considerable moisture during pulverization. This will make the dust muddy after it has been subject to cooling in the storage bins. This is especially true of bins that are exposed to a cold draft in the winter time.

Colorado lignite, so-called, is really a sub-bituminous coal and has been burned up to 22 per cent of moisture. Thirty per cent moist Texas lignites are being successfully burned by drying down to 22 per cent. The better grades of North Dakota lignite come from the mine about 40 per cent moist and can be successfully burned by drying down to 20 to 25 per cent. The reason seemingly high moisture lignites or semi-bituminous coals may thus be burned when Eastern or Mid-West bituminous could not be successfully handled with anywhere near such percentages is due to the fact that a large proportion of the lignite moisture is chemical rather than surface moisture. The moisture which appears to cause the increase in power for pulverizing and the difficulty in transporting is a surface moisture and this is not separately given in ordinary analyses of coal. Apparently the only present method of determining the correct moisture content is by trial; therefore it is desirable that pulverized fuel engineers shortly devote themselves to the establishment of definite methods of segregation of this moisture and definition of its limits, as well as the permissible limits of chemical moisture for most successful operation.

It may prove that the fineness of pulverization may have some bearing on this subject. At present our *practical* limitations of screen sizes seem to be about 200 mesh. What the proportion of very fine sizes may be with different coals at say 500 to 1000 mesh remains practically unknown. Certainly this impalpable powder content would seem to have some effect on ignition, flame propagation, and air transport. Interesting experiments have been made and are still in progress at the Bureau of Mines Experiment Station at Pittsburgh which may throw further light on this subject during the present year.

In general, manufacturers recommend for bituminous pulverization about 65 to 70 per cent passing through 200

isfactory combustion cannot be obtained with such fuel coarser than 75 to 85 per cent through 200 mesh. As previously mentioned, this fine grinding may have some bearing on the amount of moisture that can be allowed in the fuel fed to the mills but it certainly does not account for but a part of the problem, for a dense coal like anthracite, having small cells and dense structure, may always be expected to carry less surface moisture in proportion to chemical or cell moisture than the relatively loose texture, large cell bituminous, lignite, or peat.

One of the interesting recent developments in drying equipment for pulverized coal is represented by the Randolph vertical drier. Figures 1 and 2 illustrate two types, the former of which uses only heat from waste flue gases, while the latter uses stack gases in combination with steam.

It will be noted from Fig. 1 that this drier is built up in sections. A series of ports or flues extend through each section from the front to the rear. In each alternative section the ports are open to the intake side of the drier and blanked on the discharge side. In the other sections these ports are blanked on the intake side and open on the discharge side. The cross sectional view on the right-hand side of the figure shows the general arrangement of the ports. Waste heat gases are delivered to the flue which extends the full length of the intake side of the drier. These gases enter the open port sections, leaving them through the bottom which is open. Thus they pass directly through the bed of fuel into the port section just above, through which they are discharged into the discharge main and thence to a dust collector.

The coal, which is fed by gravity, travels downward through the drier in a zig-zag fashion between the ports which act as deflectors. Gases enter the drier at about 200 to 350 deg. F., leaving at about 150 deg. F. The coal is heated to a temperature somewhat below this. Many engineers believe that 212 deg. F. is necessary as the minimum temperature for drying coal. This is far from the case on account of the low pressures in these driers which in turn cause low dew-points. The drying temperature must be 25 to 50 deg. F. above the dew-point temperature, however, otherwise secondary condensation, or condensation before the moisture leaves the discharge ports, will be produced.

Advantages of this type of drier are that the hot gases entering each port are at the same temperature and same degree of dryness. The gases in the top section are just as effective as a drying medium as those in the bottom and intermediate sections. The gases are in contact with the coal only a short time, consequently being discharged before they have become saturated with moisture. Consequently none of this moisture is condensed out of the gases by having them come in contact with colder surfaces. A drier of this type can be and often is used as a storage bin for pulverizer supply. There is no possibility of fire occurring in the drier as drying is not done by high temperature gases but rather by large volumes of low temperature gases, averaging 3 lb. or less of gas per pound of coal dried, dependent upon the humidity and pressure of the drying medium, the size of coal, and the surface moisture to be removed.

Figure 2 shows a modification of the waste heat drier, showing the use of steam for preliminary drying in the two upper sections. These sections use low pressure, low temperature head steam from the exhaust or auxiliaries or bled from the turbine to remove initial moisture and thus utilize part of the latent heat which would otherwise go to the condenser. This results in a more compact drier requiring a much smaller amount of drying medium per pound of coal and much less of the fine coal is carried away in the form of dust. In installations where the preparation room is distant from the boiler room, a modification of this type, using steam exclusively as a heating medium and air as a drying medium, may be employed.

The size of drier of course depends upon the work which it is required to do for which reason driers are usually built as custom made apparatus. The factors which affect the size and design are obviously, location, space available, fineness and quantity of coal required per unit of time, moisture content of coal, and volume, temperature and

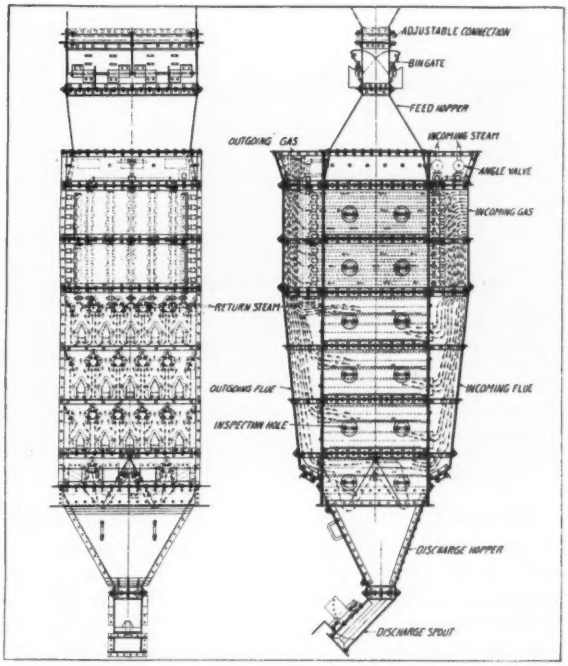


FIG. 2. THIS DRIER USES BOTH STEAM AND STACK GASES

pressure of waste gases or steam available. Two of these driers are installed at the Ford Motor Co. plant, Iron Mountain, Michigan, two at the plants of the Metropolitan Edison Co. at Middletown, Pa., and two at the Broad River Power Co., Parr, S. C.

Summing up, therefore, the user of central or western pulverized coals in central pulverizer systems will in a majority of cases require drying equipment for successful operation. The user of eastern coals must decide whether the following advantages justify the cost of driers, which

1. Increase evaporation in the boiler with a given furnace size due to greater heat release per unit of furnace volume.
2. Increase output of pulverizers.
3. Decrease power consumption of pulverizers.
4. Decrease pulverizer cleaning and maintenance.
5. Facilitate coal handling by air transport.
6. Prevent packing and arching in bins and over feeders and insure uniform flow and uninterrupted operation.
7. Reduce chance of spontaneous combustion during storage, and
8. Decrease agglomerating tendency at burner nozzles and within furnaces, thus minimizing plugging of nozzles, also deposition of unburned carbon in the bottom of furnaces and combustion chambers.

Operating Plan Cuts Industrial Steam Loss

RECORDING INSTRUMENTS, POWER DESPATCHING AND BONUS SYSTEM FOR STEAM SAVING MAKE IT POSSIBLE TO HAVE ACCURATE PLANT RECORDS, TO TRACE POWER LOSSES, TO REVISE OPERATING PRACTICES AND SECURE CO-OPERATION IN A TEXTILE FINISHING PLANT. BY HENRY MORGAN BURKE[1]

ELIMINATION of power waste is generally recognized as important but few realize that the cost of power is second only to the pay roll in a textile-finishing plant. Rising prices of fuel and labor and the unwillingness to make heavy investment in more efficient equipment for the "non-producing" power department did, however, accentuate the importance of careful study of the generation, distribution and utilization of steam and power.

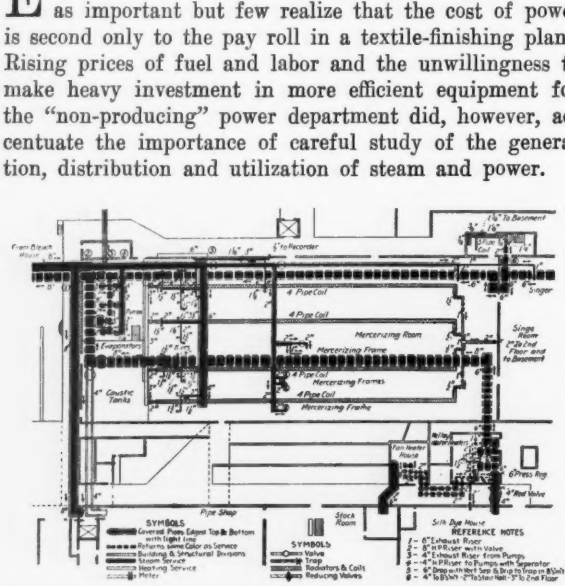


FIG. 1. COMPLETE PLANS OF THE PIPING WERE FOUND ESSENTIAL AND THOSE SHOWN HEREWITH ARE FOR PART OF THE WORKS

For 5 or 6 yr. the author and his associates had studied the plant, which was rapidly depreciating and becoming less suitable to meet the increasing growth of the productive load. Even with the use of expedients such as fuel oil, they were finally forced to face the problem squarely and solve it in the most economical manner. The answer was a new boiler plant, new methods for diagnosing daily plant operation, new operating practices, accurate records and means to enthuse the personnel to save steam and power.

Formerly the chief operating engineer was responsible for uninterrupted and economical production of power but was left to his own resourcefulness and without control over the use of steam and current by the departments of the factory. His instrument equipment was limited to feed-water meters, oil meters and draft gages but no standards of operation were established and no means available for judging how much load would be put on the plant or how it should be distributed among the boilers. Cost keeping was of the simplest, the only record being a log of apparent evaporation by weeks, based on the water fed through the Venturi meter but without account of that used for blow down, washout and leaks.

Providing steam flow meters, oil and steam pressure gages, flue-gas analyzers and pyrometers made it possible to run "standardization tests," to arouse the interest of the firemen and to furnish the engineer with a correct basis for operation. Progress was rapid and certain, responsibility was allocated and results were studied daily. Operating practice and conditions were standardized as to:

a—Distribution of load among boilers
b—Cutting boilers in and out of service
c—Regulating fires according to load and draft according to fires
d—Cleaning heating surfaces of soot and scale
e—Method of firing coal-burning boilers.

Some 73 per cent of the steam output is used for process work, the remaining 27 per cent being sent through engines and used at 7 lb. pressure for processing, heating water and building heating. Distribution of this steam presented a problem as to metering, despatching and elimination of losses and study of the conditions brought the decision that distribution and study of the losses in utilization should be taken from the shoulders of the operating engineer, leaving him responsible for generation of steam and power. Accordingly the Power Despatcher's job was created, his duties being the inspection of all distributing lines and conductors (except the sprinkler system), with valves traps, apparatus and instruments thereon, for the purpose of cutting down losses of heat, light and power in transmission; study of the ways in which steam, water and power were used so as to devise and recommend more economical operation; recording steam, water and power consumption by various departments with preparation of reports and cost charges. He had authority to schedule and specify all maintenance work on distributing lines and appliances and to draw necessary materials on requisition; to supervise work done on these lines by employes of any department or by an outside concern; to get from the heads of all departments data and records pertaining to heat, light and power used, water demands and uses, production data and practices as to delivery and consumption of heat, light, power and water; to inspect the actual use of heat, light, power and water in every department. He was held responsible to the plant engineer for uninterrupted and economical delivery of heat, light, power and water to the departments; for accuracy of records as to the use of these commodities; for securing effective co-operation with all departments to bring about the greatest practical economy in their use.

The power despatcher was given a separate office with metering, calculating and recording facilities, was paid on a salary basis but had no regular hours of work except that he was not to be requested to work more than 70 hr. a week, counting an hour of night or holiday work as two hours. All foremen of departments are expected to co-operate with him in the prosecution of his duties, failure to cooperate being considered a breach of company discipline.

CUTTING STEAM WASTES

First attack was made on the system for transporting the steam. Immediately it was discovered that a complete plan of existing piping was essential, as comfortable savings could be made by simple changes in the old layout. The complete plan of the piping showed where savings could be made in the old installation and losses avoided in making future additions. Figure 1 shows a part of the plan and the symbols used. Traps in out-of-the-way places were overhauled, listed and inspected periodically; con-

[1]Plant Engineer of the Mt. Hope Finishing Co., No. Dighton, Mass. From a paper before the New Haven, Conn., section of the A. S. M. E.

densate not fit for boiler feed was either used in the department or brought to a sump where it could be used to preheat cold water for process work. A man was specially detailed to look after traps, giving a definite part of his time each day for that purpose.

Investigation of the uses of steam revealed great opportunities for savings and made one wonder why there is so great fault found with cost of steam generation when there is such waste in utilization. "If the consumer must waste steam, make him pay for it" was adopted as a slogan, but it was easier said than done. Here was the mightiest of obstacles and all kinds of excuses that a small saving of steam would affect the quality of the product. If steam could be saved in large quantities, who was to say when and how long steam should be used every minute of every day of every week? It was difficult for the power despatcher to estimate losses, recommend better practice and see that his recommendations were carried out; still harder to convince department heads that they were wasting steam and should take orders from a man who knew less about the product than they did. Of course, a bonus would help but how could a bonus on the use of steam be figured un-

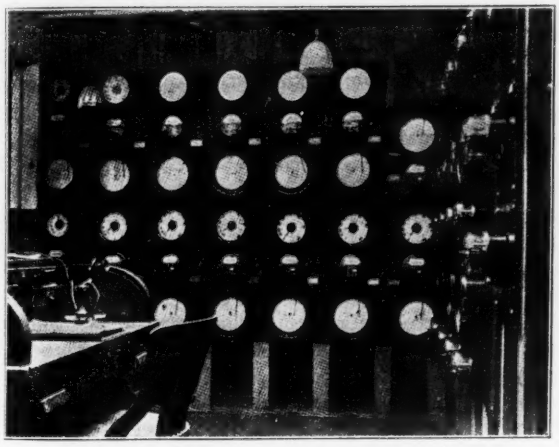


FIG. 2. METERS ARE PLACED ON CENTRAL PANELS IN THE DESPATCHER'S OFFICE

less it was definitely known how, when, where and in what quantities steam must be had by the various departments?

Metering Solved Steam Problems

Too much red tape, too many records, too much interference with the work of a department might make the despatcher's work too great and offset the savings. So, at first, a few meters were installed in the departments using the greatest amounts of steam. Results were so gratifying that installation was continued until every pound of steam generated could be accounted for.

If meters were to be read every day at the point where the steam was used, meter readers would be an added expense. Consequently it was decided to use an electrically operated instrument that could be centrally located in the despatcher's office where he could see at a glance how the different users were drawing on the steam supply. An unexpected draft on the boilers was known at once and investigated by telephone so that, if the draft was to be permanent, the engineer could be instructed that more steam would be required for a definite period. If a big steam user closed down without advising the despatcher, (a thing they will do unless the use of steam affects their pay), the fluctuation was noticed, the reason found and the engineer advised that less steam would be required. This enabled the engineer to effect economies in the boiler room that could not otherwise be attained.

Recording charts in connection with production figures make it possible to show departments where they are using more steam than the standard allowable for a given period and, with a bonus paid on steam saving, is a valuable help to the despatcher, foreman and engineer in reduction of operating and maintenance costs. If it seems best in the interest of economy to have a recording chart in an office or department, all that is necessary is to run a pair of wires and set up the meter. In some instances it was

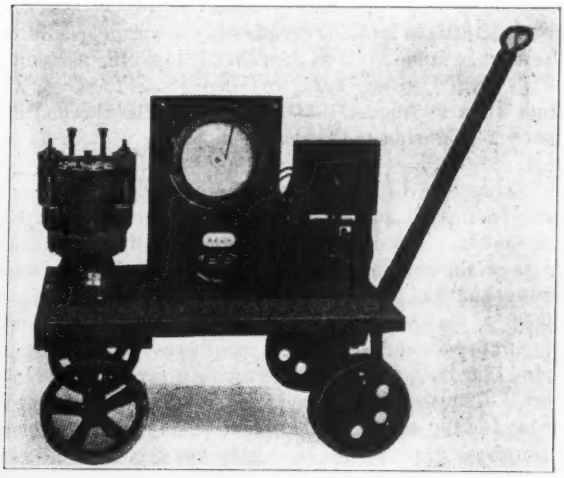


FIG. 3. FOR TEST PURPOSES, A PORTABLE STEAM FLOW METER IS MOUNTED ON A TRUCK

found wise to set up a recording meter in the department and a recording meter with integrator in the despatcher's office. Figure 2 shows the central metering panels, and Fig. 3 a portable outfit for tests.

Take Care of the Meters

Any system will be of no avail unless cared for and metering devices do require care, although not so much as the non-believer in them would have one think. But, if one is looking for better ways to reduce cost and prevent steam waste, he will keep his instruments in first class condition in a systematic way, which can be done at negligible expense. If the steam user is being charged too much or too little, it will be reflected in his bonus. If that increases abnormally, the cost department will investigate; if it decreases, the employe will look into the recording of the meter. If the power despatcher inclines to take things easy, the chief engineer will "want to know," for production of unnecessary steam is reflected in the monthly cost figures of the product and this takes money out of the engineer's pocket. Instruments scattered around in dark corners permit laxity of the person caring for and using them; hence, all instruments are centralized, where possible, or located at points nearest and most convenient to those using them.

Previous to the beginning of the work, as shown by preliminary observations from January to March, 1922, the ratio of apparent evaporation at the plant averaged 12.55 lb. of steam per pound of fuel oil. Figure 4 shows the

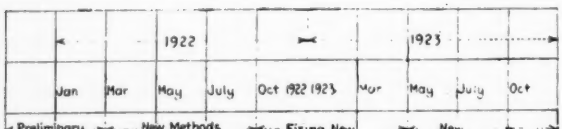


FIG. 4. STEADY PROGRESS IN EFFICIENCY WAS MADE AFTER THE NEW METHODS WERE ADOPTED

progress made in building up efficiency of steam generation, the average from April to Sept. being 13.25 lb., per pound of oil from October, 1922, to May, 1923, 13.87 lb. and from June to August, 1923, 14.21 lb. The thermal efficiency rose during the period from 72 per cent to 83 per cent.

Savings in distribution were in addition to these and came from study and changes in operation of the distributing system. By shutting off main pipe lines to distant parts of the works over week ends and by heating warehouses and like rooms to lower temperatures, a saving of $3000 a year was made. Reducing pressure in caustic evaporators brought the steam used per pound of caustic from 11.6 lb. down to 9.06 lb., with a saving of $3800 a year. Using exhaust steam instead of live for heating water for the silk dye department and reducing temperature of the water from 210 deg. to 110 deg. gave a saving of $20,000 a year. Heating of water for dolly washers, using low pressure instead of high, resulted in a saving of $3200 a year. Later, by stage heating, using exhaust to heat to 150 deg. and 40-lb. steam to heat to 210 deg., an additional saving of $5400 a year was effected.

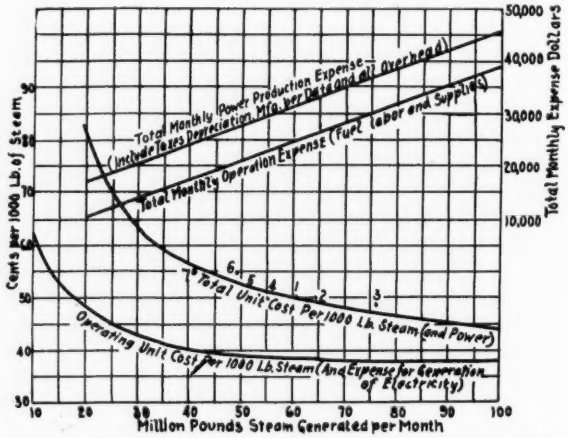

Cents per 1000 Lb. of Steam
Total Monthly Expense Dollars
50,000
40,000
30,000
20,000
10,000
Total Monthly Power Production Expense (Including Taxes Depreciation Mfg. per Data and all Overhead)
Total Monthly Operation Expense (Fuel Labor and Supplies)
Total Unit Cost Per 1000 Lb. Steam (and Power)
Operating Unit Cost per 1000 Lb. Steam (And Expense for Generation of Electricity)
Million Pounds Steam Generated per Month

FIG. 6. STEAM COSTS ARE COMPARED WITH THE CURVES PLOTTED FROM DATA OF A 5-YR. RECORD

Records Check Performance

Records are of utmost importance to carry on work as planned, control progress and maintain interest of the men responsible for performance. Simplicity, minimum number of forms and crystallization into one result chart has been the endeavor. This result chart is on fuel utilization and is shown in Fig. 5. Each day there are three shifts in the boiler room and the day is divided into fifteen sections corresponding to 15 lb. evaporation per pound of oil. The line for each shift for the day shows the evaporation performance for that shift and the heavy line, the average for the three shifts. The line for the week shows average attainment for that week, the figures under "notes" showing the fuel allotted for the load carried, actual fuel used and the fuel saved or wasted. This chart is posted in the boiler room and is a subject of interest to the force on a par with the baseball score.

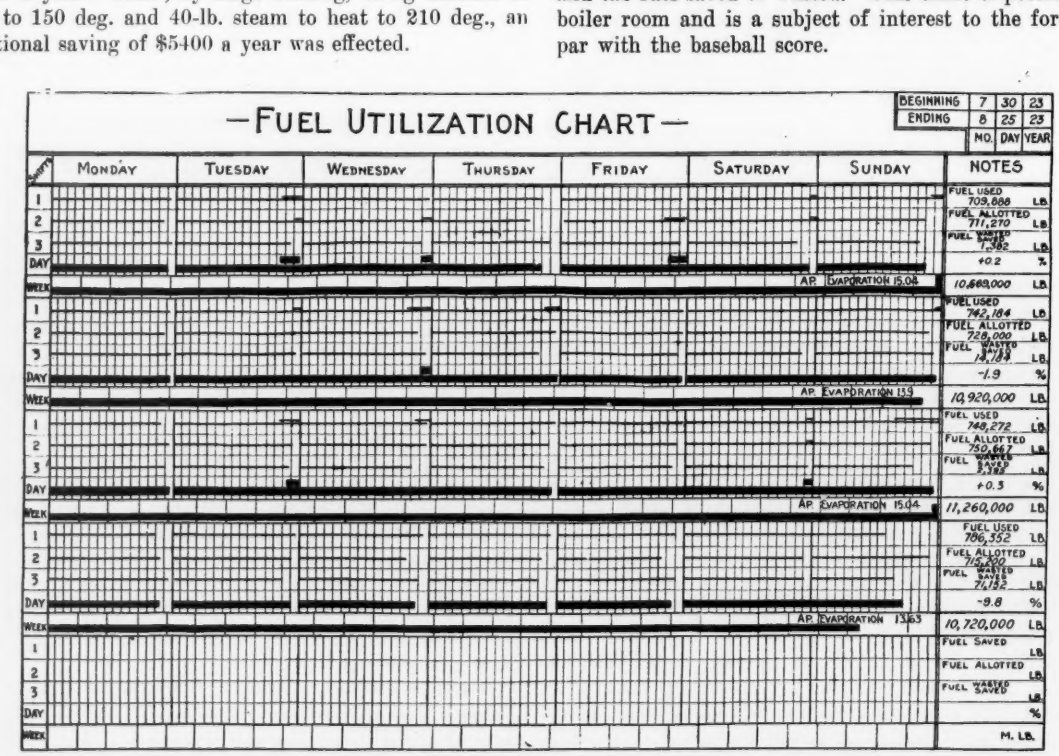


FIG. 5. FUEL CONSUMPTION IS CHECKED BY SHIFTS, BY DAYS AND BY WEEKS

From the distribution records, the despatcher compiles the steam and power costs for departments, the cost per 1000 lb. of steam and the cost per unit of merchandise processed. The power plant is operated as a virtually independent business which buys raw product, fuel, and sells steam to its customers, the various departments. It pays rent, taxes, insurance and other fixed charges and for labor and supplies, hence charges for lighting, power and steam—its finished products. Live steam cost runs from 45 to 57 cents per 1000 lb. and exhaust is charged at 35 cents per 1000 lb. For the month of August, 1923, the actual evaporation per pound of oil averaged 14.4 lb., equivalent evaporation, 15.49 lb., thermal efficiency 82 per cent. The steam per yard of cloth was 6.7 lb.; per pound of cloth, 28 lb.; exhaust steam 34 per cent of the total; cost of live steam 51 cents per 1000 lb.; of exhaust steam 22 cents per 1000 lb.; of electricity 1.12 cents per kw-hr.

Each department is billed weekly for the steam and current used as shown by steam flow and electric meter readings; also the accounting and sales department is given a monthly report of power expense to various departments with statement of items which make up the various costs and comparison with the same items for the preceding month.

Each month the actual costs are compared with a chart of predetermined costs shown in Fig. 6, this chart being based on data collected over a period of 5 yr. It is useful in detecting errors in accounting and allocating charges to the power department and it is interesting to see how closely the actual and predicted costs coincide.

This system is simple and elastic. It can be applied, in principle, to a large or small plant and for any product. It brings into the works organization the spirit of efficiency, cooperation and contest among employes yet has involved addition to the pay roll of only one man, the power despatcher. As the plant was operated at unusually high efficiency before the installation of the new methods, the savings are the more remarkable.

The Ghost in the Power Plant

By William M. Griffin*

INDUSTRY'S march of progress has been a series of conquests by the mind of man. Great problems have arisen and have been solved. Great sources of loss and wastage have been revealed and have been eliminated. So rapid and so constant has been the progress of industry's triumph over known agencies which hinder its economic development that today, from most viewpoints, the average industrial plant is a nearly perfect organization.

The executive knows what return he is getting for the wages he pays. He has experts to accelerate production. His costs are an open book to him. Handling of materials has been so systematized that loss of time and energy is minimized. Time study has contributed its share to perfecting the industrial organization. Obviously, one must consider American industry highly efficient.

But, though such apparently ideal conditions exist, there is one department, and that at the very heart of the industrial establishment, that has, to a considerable extent, not received the effort that has been directed toward development of other phases. We speak of the industrial power plant.

When one considers that the annual payroll of American industry exceeds ten billion dollars, and that the cost of power to operate it is equal to one-fourth of that great figure, he has some conception of the relative importance of the power plant. Then, if he goes a step further in his investigation and finds authentic figures which prove that the cost of power in the average industry is just about twice what it should be, he finds a field which offers great opportunities for improvement. Most authorities agree that this condition exists, because of the average executive's unfamiliarity with the power plant. He does not know how much a dollar paid for power should produce. He is prone to consider the power plant as being "good enough as it is" and to accept its operating costs as a necessary evil, so his power continues to cost just about twice what it should. And it will continue to cost him that excessive amount until he comes to a realization of how much may be saved by application of such economies as he practices in his other departments.

More than a billion dollars is dissipated each year through wastage and loss of efficiency in power plants in the United States. The reasons for this loss are many

*President of the Wayne Tank & Pump Co.

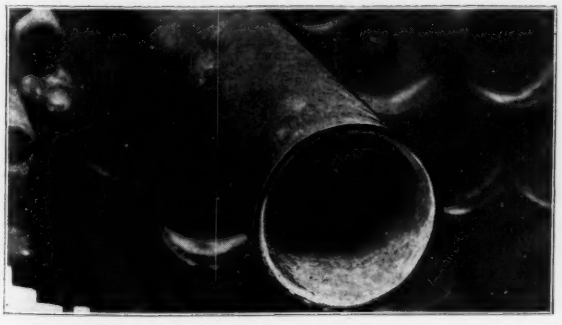


FIG. 1. CLOSE UP OF THE "GHOST" IN A WATER-TUBE FROM A BOILER

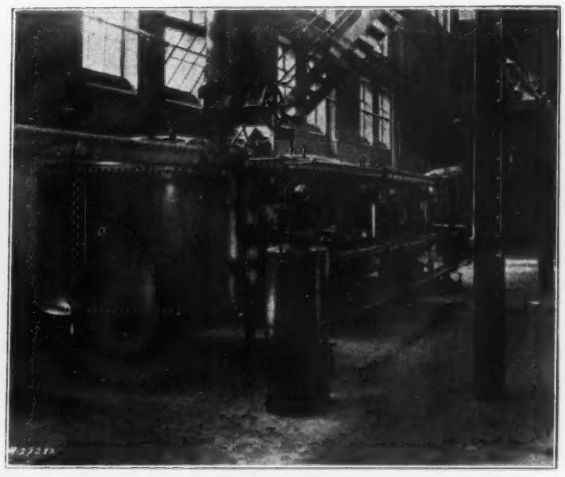


FIG. 2. THIS PLANT IN MILWAUKEE FILTERS AND SOFTENS RIVER WATER FOR BOILER FEED

and vary with conditions in different parts of the country. Some sources of large loss in one instance may be minor considerations in another, but one important factor is boiler scale.

Boiler scale might be considered the ghost of hard water. The water is used, serves its purpose as well, or as poorly, as it may and passes out of the picture; but its ghost remains as the scale it has deposited in the boiler. One might visualize the ghost running up and down the tubes and through the boiler, waving its arms as if defying the boiler to perform its proper function, chortling in ghoulish glee as it contemplates the extent of its devastating influence. The ghost preys on the coal pile or other fuel supply too, mocks the stokers as they work harder and

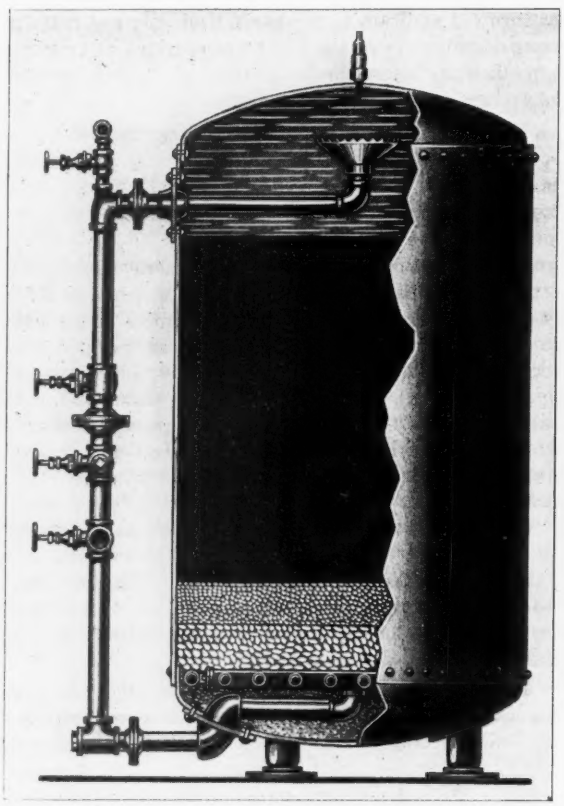


FIG. 3. SECTION OF A MODERN ZEOLITE SOFTENER, WATER SPREADER AT THE TOP, WITH ZEOLITE AND 2 LAYERS OF GRAVEL IN THE CENTRAL PORTION AND COLLECTOR SYSTEM FOR SOFT WATER AT BOTTOM

harder to keep the pressure constant, yet see their efforts thwarted despite their additional work. One may well believe that, in the course of a year, the damage, loss and wastage caused by this ghost of hard water become items of great importance.

Hard water scale in boilers or hot water systems of any kind, is caused by the precipitation, by heat, of the minerals dissolved in the water, principally lime or calcium and magnesia. There is nothing vague or strange about the presence of boiler scale. It follows the use of hard water in steam plants as surely as anything under the sun.

Engineers have been combating boiler scale since the first steam plant got into trouble and scale was discovered as the cause. When it was realized that soft water was the only method of successfully preventing scale accumulation, the problem then was to provide soft water. And the mechanical water softener lays the ghost.

While the mechanical water softener has been known for a number of years in one form and another, its perfection has been so comparatively recent that even some engineers lack thorough knowledge of the development of what is known as the "base exchange" softener. This softener derives its name from the process involved in its operation. The hard water that runs into the softener contains lime and magnesia. It passes through a mineral bed which acts as the softening agency and converts the lime and magnesia or hard scale compounds to corresponding sodium compounds without hard scale forming properties.

Since it is now possible to prevent the formation of boiler scale, the power plant can overcome this source of loss. There are other sources of waste and loss of efficiency, of course, but scale, in communities where water is of sufficient hardness to cause heavy formation, and 65 per cent of the territory in the United States is what is known as hard water territory, is without doubt one of the most costly sources. In the first place, the scale serves to insulate the tubes against passage of heat.

Tests at the University of Illinois showed that scale as thin as 1/50 in. resulted in a loss of efficiency of 5.4 per cent; $\frac{1}{32}$ in., 7.2 per cent; $\frac{1}{16}$ in., from 10.8 to 12.6 per cent, depending upon the chemical qualities of the scale; and 1/9 in., 15.9 per cent. So that a water softening plant gives opportunity for large and secure dividends and safeguards a considerable investment of money in the power plant.

The United States Bureau of Mines reports profits of from $2300 to as high as $4970 a year on investments of $7000 to $7200 in water softening plants. In one case, a softener for a plant of three 200-hp. boilers was installed at a cost of $3000, or $5 per boiler horsepower. The coal consumption dropped from 1400 to 1260 tons a year, the difference at $5 a ton representing a saving of $700. The saving in labor cost, however, by the elimination of boiler cleaning, was even greater, being calculated at $1040. Subtracting from this total of $1740 the sum of $140 for interest, depreciation and operation, the net saving figures out at $1030, without taking a number of other economy items into consideration.

A New York manufacturer of carriages and wagons affords a good example of large gains in a small power plant through the installation of a water softener. Two 205-hp. vertical water-tube boilers supply the steam used by this concern, working with an overload factor of practically 100 per cent for ten hours a day and carrying a light load for the balance of the 24 hr. An artesian well supplies the water for these boilers. It is clean and clear but contains 15 grains of hardness, which means that it carries 2 1/7 lb. of scale for every 1000 gal. The result was that, when the water was used in its natural state, scale from $\frac{1}{16}$ to $\frac{3}{32}$ in. thick had to be removed manually from the boilers every four weeks. The softening equipment delivers 12,000 gal. a day of soft water. Within a month after its installation, the consumption of coal had dropped from 7.5 T. a day to 5.5 T., an annual saving of some 600 T. At the convenient figure of $5 a ton, this equals $3000 saving a year.

An even more striking example of the money-saving properties of soft water is contained in the experience of one of the several plants of a large eastern manufacturing

company. This plant operated water-tube boilers at high steaming rates. Small spots of scale had formed on the tubes causing them to blister and burn out to the extent that the cost of shutdowns, tube replacements and other items of expense incurred every 60 days was about equal to the cost of the water softener installation with which the power plant was finally equipped.

With soft water which is now used, no tubes have been replaced during a period of 10 mo. operation. The engineer in charge declares the investment in water-softening equipment in this plant is paying out regularly, over and over again, about once every 3 mo. and taking care of the operating costs besides.

Today, any size of power plant may know the savings effected by use of the base exchange water softener. Progress in its development and production makes its use not only possible and practicable but decidedly profitable. So flexible and economical is the operation of the base exchange softener that its application is beneficial and profitable in practically every industrial steam plant. In hotels, hospitals, laundries and textile mills the modern water softener is more than paying its way in hundreds of installations and in homes the economy and desirable convenience of soft water is creating a tremendous market.

Referring again to the yearly cost of power plant operation in America, which, as has been said, amounts to one-fourth of the total wages paid, or approximately two and one-half billion dollars, one might be inclined to the opinion that American industry was getting ample returns from its investment. But power costs twice as much as it should and the ghost of hard water, devastating boiler scale, is one reason.

Some Tendencies in Modern Power Plant Design

BUILDINGS, COAL AND ASH HANDLING, METHODS OF FIRING, BOILERS AND SETTINGS, ECONOMIZERS, AIR PREHEATERS, TURBINE SIZES, CONDENSERS AND AUXILIARY DRIVE. BY WALTER M. KEENAN[1]

IN CONSIDERING the prospects for a new plant or enlargement, it is interesting to glance at the process by which the plant gets started. It is the business of the engineer to be looking ahead and estimating the future needs of the plant, to study load curves and their tendencies and, when it seems that the margin between power plant capacity and load demand will, within a year or two, become too small, to present to officials the need for increasing generating capacity. Then will come study of the present state of the art of plant design, kinds of equipment, types and sizes of boilers, turbines, condensers, coal and ash handling apparatus, electrical equipment and auxiliaries. These points will generally be determined by the kind of load factor that the plant will have, sizes manufacturers can offer for local conditions, and the experience of the company and others with various installations. Plans will usually be made to take care of a 10-yr. or more expansion of business at the estimated rate of natural increase.

Next, available locations will be discussed, the points stressed being the center of load, available water, railroad or barge facilities for coal delivery, land values and room for coal storage. Estimates are made as to probable cost and this is one of the sacred mysteries. Suffice it to say that experience is by far the most important factor entering into the estimate of cost.

With these figures and plans, the engineers and officials decide on a course and plan the attack on the local Wall Street. The financiers enter the arena and the engineers sit back to await the outcome.

ALLOTMENT OF BUILDING SPACE CHANGING

As to outside design, it is well to keep in mind that the building is merely an envelope for the equipment and that arrangement of equipment should never depend upon building design. The writer favors simple architectural lines with moderate ornamentation. Recently considerable attention has been given to providing quarters for employes such as two lockers for each man, one for clean clothes and one for soiled, shower baths, lavatories, lunch rooms, general meeting rooms and office room for superintendents and chief operating engineers. Laboratories are also provided with testing equipment for checking up on plant apparatus and operation which, in variety and first cost, rivals that of many technical colleges.

Study of typical plants erected during the past 25 yr. will show marked changes in the relative spaces occupied by boiler, turbine and switch house. In the earlier years, with reciprocating engines largely in use, the engine room was large in comparison to the other two and electrical galleries had little space. In modern plants, the boiler room has about the same as or possibly larger volume than the turbine room and electrical galleries occupy a space almost as great, many plants having outdoor switching equipment. Isolated phase arrangement is receiving much attention, the three phases being widely separated to prevent short circuits between phases. Disrupting capacities of modern circuit breakers, whether for a large station or for a small station connected to a large system, are of tremendous values. In the Hudson Ave. station of the Brooklyn Edison Co., this capacity is 1,500,000 kv.a.

In one plant in New York, a novel method of installing conduit was developed. Rubber tubes are laid on the floor or against walls where cables are to run and covered with concrete; after 24 hr. the hose is pulled out, leaving a perfect conduit, smooth and uniform in size. This method is now being used also for underground transmission conduit and is proving a very economical construction.

COAL AND ASH HANDLING

For raising coal from barges, steamships or coal pits adjacent to railroad sidings, electrically operated towers are now considerably used, many of them operating at high speed. The Hell Gate towers run at 1800 ft. a min., handling 250 t. an hour. Either a.c. or d.c. may be used for operating these towers. For distributing coal to the bunkers, belts, cable roads or electrical roads are used extensively. The electrical roads are automatic, operating without a motorman, automatic scales weighing the coal in cars without stopping or on belts as the coal passes over. Weigh lorries are frequently used for distributing the coal to individual boilers in stoker-operated plants. These enable the operator to keep a record of the coal fed to each boiler. For outdoor storage, the drag line scraper is simple, cheap, has given satisfaction and does not require a skilled operator.

[1]Asst. Engg. Mgr. of Thomas E. Murray, Inc., New York. From a paper presented before the Rochester section of the A. S. M. E. and the Rochester Engineering Society.

In the handling of ashes, the principal development has been the use of sluices or water troughs which carry the ashes to a pit from which they are taken by perforated buckets or equivalent means. This is clean, requires the minimum of labor and, in a plant like the Hell Gate station, permits the handling to be done by one man.

Pulverized Fuel and Stokers

Since the first successful large installation for burning powdered coal at Milwaukee, the relative merits of these two systems has been much argued. Recent improvements in stokers have greatly increased the possible efficiency that may be obtained with them but efficiencies with pulverized fuel have been somewhat higher and have a more sustained value through a wider range of boiler load. The argument hinges on the initial costs, efficiencies obtainable, maintenance of efficiency over a load range, safety, reliability, flexibility and ease of operation, cost of operation and maintenance and dust nuisance. Final decision as to which method to use rests on the weighing of all items and the local conditions in a given case.

At the Sherman Creek plant of the United Electric Light & Power Co., six boilers were installed, equipped to burn pulverized coal by various systems so as to decide which system will be best adapted for use in extensions of this company's plants but results are not yet available. In the Hudson Ave. Station, all boilers are equipped with stokers. The new East River plant in New York is to have pulverized fuel equipment. Hasty selection of either system should not be made, in fact, future methods of using fuel may lead far afield from either of these methods.

Boiler Sizes and Settings

Recent tendency to increase the size of boilers has, in the opinion of the writer, reached its limit and the swing is toward more moderate sizes. Boilers originally installed in Hell Gate station, purchased in 1920, were rated at 1890 hp. Those purchased in 1923 were 1590 hp. and those for the 7th row, purchased in 1925, were 1210 hp. In the Hudson Ave. station, boilers bought in 1922 were of 1965 hp., those bought in 1925 for East River were of 1590 hp. The reason is that with boilers recently purchased, more economizers are being used and the height of the boilers is being reduced.

Ordinarily, the best working point for the stoker-operated boiler is at about 175 per cent of rating. On peak load, they are often forced to 300 per cent but at these high loads, the furnace temperatures may have bad effects on the furnace walls. To cut down furnace wall maintenance, Mr. Murray installed three boilers at Hell Gate with tubes in the side walls, connected directly into the boiler circulation. They were spaced about the same as the boiler tubes but provided with fins extending from each side and overlapping so as to present a metal wall to the inside of the furnace. Tests were run to determine the output to which one of these boilers could be forced and over 600 per cent was obtained for a short time, with 500 per cent easily maintained for indefinite periods. The limit was set by the induced draft fan motors and boiler feed pump capacities, features apart from the boiler and furnace proper. Efficiencies were remarkable, being 84.6 per cent for the boiler and 92.7 per cent for boiler and economizer at 181 per cent of rating.

Side wall maintenance for pulverized coal plants becomes even more of a problem since the temperature for such furnaces runs higher and some means of cooling the walls is more imperative. Water-cooled walls have also been tried for these and, so far as the writer knows, have been satisfactory. When side walls were first put in at the Sherman Creek plant, which burns powdered coal, there was some doubt as to whether combustion could be started and maintained on account of the low temperature of the walls of the furnace. When the first boiler was started, the engineers could not ignite the coal and the calamity howlers said, "I told you so." But the difficulty was found, after two heart rending days, in the feeding device of the pulverizer and when this was remedied, firing was started and kept up without difficulty. These furnaces are small in comparison with usual furnaces for powdered fuel, yet efficiencies of 80 per cent and over are readily obtained.

Economizer Surface Growing—Air Preheaters on Trial

Long has the question of use of economizers been debated, with figures to show great savings being presented on both sides of the controversy. At present, use of economizers seems to be more general, accompanied by cutting down in the height of the bank of boiler tubes. On the boilers for the East River station in New York, having 15,900 sq. ft. of heating surface, 14,000 sq. ft. of economizer surface will be used.

Air preheaters, for recovering heat from the flue gases after leaving the boiler, or in some cases after leaving the economizer, are being tried in some plants. The heat is passed into the air which will be used for combustion in the furnaces. These heaters are of three principal types; the tubular, having the gases on the outside of tubes through which the air flows; the plate, in which plates are used to form adjacent passages for the gases and the air; and the rotary type, in which plates are passed through the gases and heated, then passed through the air to give up their heat to it. Use of such preheaters is not becoming general as rapidly as was anticipated a short time ago, one of the chief reasons, as the writer sees it, being the space required to bring the air to and from the preheater and the boiler furnace.

Turbine Practice

Turbine sizes have increased rapidly in the past few years being 30,000 to 35,000 kw. in 1919; 35,000 to 40,000 kw. in 1921; 50,000 kw. in 1922 and 1923, and 60,000 kw. at present. Even 75,000 kw. was considered for the East River plant. As the writer sees it, these figures are not so remarkable so far as turbine design goes but they do show the big blocks of power that these new stations can afford to drop by having to shut down a single unit, without affecting service to customers. Improvements in design have, however, about kept pace with growth in size, better water rates being due largely to painstaking calculations and tests made by manufacturers. Rankine cycle efficiency ratios of about 80 per cent are now obtained in large apparatus.

Steam pressures and temperatures are creeping up so that 700 to 750 deg. is more or less conservative, at present. Without exceeding this temperature, pressures up to 1200 lb. are being tried in large plants. Steam conditions in the East River station are 350 lb. and 700 deg., corresponding to a superheat of 260 deg. The temperature rather than the pressure is the limiting condition. We can design to take care of any pressure but materials are not suitable to handle very high temperatures. Water rates for East River are 9.25 lb. per kw.-hr., for the first Hell Gate station, 10.35 lb. and for later ones about 10.1 lb.

Condenser surface per kilowatt of turbine capacity varies considerably in modern stations. On large turbines, the sizes of condensers becomes enormous, those for the Hudson Ave. station having 70,000 sq. ft. There is a tendency to cut down on the surface and condensers have been developed and put into successful operation on this basis. The means used is increased water velocity in the tubes, proper spacing of the tubes to give efficient use of all the tube surface and rapid and complete withdrawal of the non-condensable gases from the condenser.

Auxiliary Equipment

Pumps, fans, air compressors and other equipment about a plant require power for driving and many of these must have a reliable source of power for, if they stop, the whole plant will be shut down. Naturally electric power station operators desire to use motor drives for all apparatus but they must generate their product, electricity, at as low cost as is consistent with continuity of service. If the heat in the exhaust steam can be entirely recovered, generation of power by steam turbines becomes very cheap and losses inherent in generating and transmitting electricity are absent. On the other hand, water rates for small turbines are not so low as for large units. Selection of auxiliaries and drive is a problem that must be solved for each station to fit local conditions. In Hell Gate and Hudson Ave., practically all drive is by motors, while in East River, practically all will be by steam. The writer believes that future drives will be electrical but this will more or less await a cheaper, reliable, variable speed, highly efficient a.c. motor.

Heat balance, about which there was much discussion a short time ago, really covers two things; the means of heating feed water and the B.t.u. supplied for production of a kilowatt-hour. With full motor-driven auxiliaries, the heat for the feed water is usually had by bleeding the main turbines, either with or without economizers. With steam-driven auxiliaries, exhaust from them largely displaces the use of bleeding from the main units. Hence, the problem of auxiliary drive is tied in with that of the heat balance. By careful study, economy in modern stations has shown steady improvement until values of under 18,000 B.t.u. per kw-hr. are more or less general in the new plants.

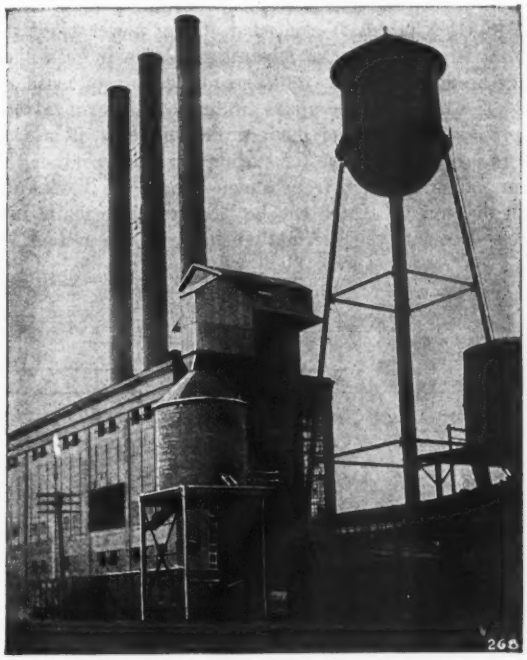
Storage Bin Replaces Coal Bunker

Coal Is Spouted From This Outdoor Bin to a Weigh Larry Which Feeds the Stoker Hoppers

COAL HANDLING at plant No. 18 of the Fisher Body Co. has been provided for in an unusual manner in that coal storage for the stokers has been obtained without resorting to an overhead bunker in the boiler room. The coal handling installation consists of a 500-T. capacity steel storage bin, 20 ft. in diameter and 55 ft. high; a track hopper; reciprocating plate feeder; a 20 by 30-in. two roll crusher; a 20 by 15 by 7½-in. gravity discharge conveyor and a 1-T. power propelled weigh larry. The ash handling system consists of a 20-cu. ft. capacity ash skip; a 40-cu. ft. capacity steel rocker bottom ash car and a 16-ft. diameter by 16-ft. deep reinforced tile silo.

Lump coal is brought to the property, discharged into the track hopper and fed by means of the plate feeder into the two roll crusher, which reduces it, at the rate of 50 T. per hr., to 1¼ in. and smaller. It is then discharged into the gravity discharge elevator and elevated into the steel storage bin. The arrangement providing for this steel storage bin by the Stearns Conveyor Co. is unique, in that it provides a live storage of 60 T. As soon as this live storage bin is filled the coal flows to the reserve storage. One of the vital points of this arrangement lies in the arrangement which insures against coal going to the reserve storage until the live one is filled.

Coal from the live storage is spouted directly to the boiler room weigh larry which travels the entire length of the plant. The weigh larry is power propelled and arranged so the operator can ride on the machine when filling the stoker hoppers. On the scales is provided an automatic feature incorporating a card punching system, so that the operator can keep a record of the amount of coal which has been delivered to each boiler.

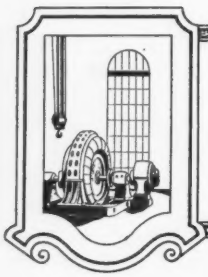


COAL BIN PROVIDES BOTH LIVE AND RESERVE STORAGE

In addition to the coal in the live storage, this installation provides a reserve storage of 440 T. This can be drawn from the lower portion of the bin by means of an automatic feeder and re-elevated into the live storage, so that the fuel is at hand when needed.

This type of coal handling equipment makes it possible for the architect or builder to design a power plant entirely independent of a coal bunker, which has generally had to be placed inside of the building. It affords better light and ventilation and eliminates the necessity of heavy columns required to support the weight of the bunker and coal.

In this installation ash is drawn from large storage bins underneath the stoker and is then discharged into a rocker bottom dump car. The car has a capacity of 40 cu. ft. and is mounted on large diameter wheels, operating on roller bearings. The ash is discharged into a storage hopper alongside of the ash track, from which it is delivered to a 40-cu. ft. capacity ash skip which discharges it into the ash storage silo. Construction to the floor of the silo is such as to provide a drainage away from the lower openings, thus preventing freezing of ash in the winter from blocking the openings. The ash is delivered to railroad cars by two hinged and counterweighted spouts.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Electric Power Systems for Auxiliaries

INCREASE IN THERMAL EFFICIENCY OF STEAM CYCLE HAS MADE THE USE OF ELECTRICALLY DRIVEN AUXILIARIES A NECESSITY

IT IS GENERALLY conceded among power plant men that in order to take advantage of the increased efficiency brought about by multi-stage bleeding of main turbines, the use of economizers, water-cooled furnace walls, air preheaters and other modern developments, it is necessary to use electric drive for station auxiliaries rather than steam. The exhaust from steam-driven auxiliaries cuts down the amount which can be bled from the main units, thereby lowering the thermal efficiency of the system.

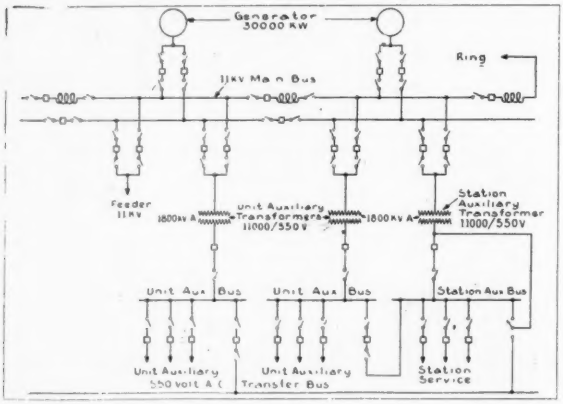


FIG. 1. TYPICAL UNIT POWER SUPPLY FOR A.C. AUXILIARIES MAIN BUS

This general question of auxiliary drives in central stations was discussed by a number of engineers at a meeting of the Schenectady section of the American Institute of Electric Engineers held some time ago. One of the papers read at this meeting, "Power Supply for Central Station Auxiliaries," by J. W. Dodge, of the General Electric Co., discussed the relative advantages of various systems used for producing the electrical energy needed for the auxiliaries. This article is an abstract of Mr. Dodge's paper.

Briefly stated, the sources of electric power which may be used for the supply of auxiliaries are as follows:

(1) Main generators or main bus
(2) House generators coupled to main unit
(3) House turbine generator sets
(4) Power from some other station

The latter is usually considered only as an emergency supply.

Usually, the main generator is regarded as the most reliable unit in the power plant. It is connected to the distribution system, however, and therefore it is more or less subject to system disturbances, depending on how well the busses and feeders are sectionalized by current limiting reactors and automatic switches. In general, the

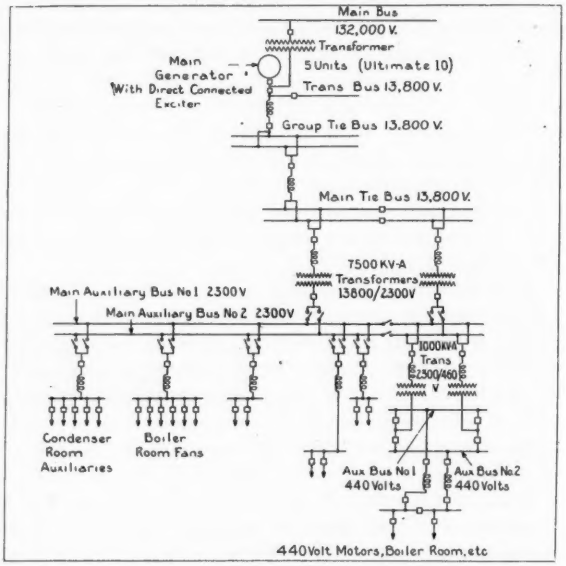


FIG. 2. POWER SUPPLY FOR AUXILIARIES FROM MAIN TIE BUS

This system is used on the basis that this is the most reliable power supply in the station, being fed from all the generating units and in many cases from ties to other plants. The auxiliaries are grouped on feeders with current limiting reactors.

larger systems are laid out so that a feeder short circuit will not cause sufficient drop in voltage at the bus seriously to affect equipment operating on other feeders. This would mean that only a station bus short circuit would pull the voltage down sufficiently to interrupt service on auxiliaries supplied from the main generators. With isolated phase arrangement of all main bus and switching equipment, such a bus short is a very remote possibility. Even assuming a dead short circuit on a section of the main bus, the operation of auxiliaries on other units need not be disturbed if each main unit is operated on a bus section from which its auxiliaries are fed, and each section provided with differential relay protection, such as is used on the generators and transformers. Such protection has already been provided in a large hydroelectric plant, and is being considered for steam stations. Figure 1 shows a station connection diagram adaptable to this scheme of operation.

The main generator is, of course, the cheapest producer of electric power in the station, and has a lower first cost per kilowatt than other generating equipment which might be used for supplying power for auxiliaries. It also has the advantage of making a simple station layout, with no auxiliary turbine generators to provide space for in the station, or the extra steam lines, switching equipment, etc. necessary where they are employed.

Another scheme that may be used is to take the auxiliary power from the main synchronizng bus of the station, on the basis that this is the most reliable power supply in the station, being fed from all the generating units and in many cases, from ties to other plants. Figure 2 shows such a layout being used for a large central station now being designed, where all auxiliaries will be electrically driven.

Auxiliary Generator Coupled to Main Unit

The use of a second generator connected to the main unit makes possible a separate electrical system for the auxiliaries, not connected in any way with the main system, and therefore, free from system disturbances. This auxiliary generator may be of sufficient size to supply all the auxiliaries for the unit, or it may be made only large enough to supply the essential auxiliaries (boiler feed, circulating pump and excitation) which must be kept going regardless of system troubles. In case the auxiliary generator is to provide power for all the auxiliary motors for one main unit, its capacity will be 5 to 6 per cent of the rating of the main unit. This assumes that certain auxiliaries such as coal and ash handling equipment, station lighting and other common station service will be supplied from the main bus through transformer.

If only the excitation, boiler feed and circulating water pumps are taken from the auxiliary generator, its rating will be about two and one-half per cent of the rating of the main generator.

The auxiliary generator can be of extra rugged construction with extra insulation (since it is a low-voltage machine) and it will naturally be a conservative machine, as its rating is small compared with the main generator which operates at the same speed. Such a unit is shown in Fig. 3. The auxiliary generator is ordinarily 2300 v., 3 phase, 60 cycles and equipped with a direct-connected exciter for voltage regulator operation. The auxiliary generator somewhat complicates the question of excitation for the main unit, as either a motor generator exciter must be used supplied from the auxiliary generator, a second direct-connected exciter added to the main unit, or one direct-connected exciter used for common excitation of both main and auxiliary generator.

The motor generator seems to be a desirable scheme of excitation for the main unit since the use of two direct-connected exciters makes an extremely long main unit, unnecessarily complicated, and the use of one common exciter for both units does not give a flexible combination. It is impractical to use a Tirrill type voltage regulator on either main or auxiliary generator where a common exciter is used. The operation would be limited to the use of constant exciter voltage with either a manually controlled main field rheostat for each generator or an automatic face plate voltage regulator in the main field circuit of the generators. Either of these excitation control schemes involves extra loss in the main field rheostat and does not have the advantage of Tirrill regulator voltage control. With a separate exciter for each generator, the field excitation may be controlled by varying the voltage of the exciters as the operating conditions demand, without affecting the other machine. This largely eliminates generator field rheostat loss and also permits the use of either hand or automatic control for either unit, as desired. The auxiliary generator is built on a base and bearings of its own, which, with the small exciter can be removed as a unit from the main bed plate in case the rotor must be removed from the main generator.

Since space must be provided in the main generating room for removing the rotor lengthwise out of the main generator, it has been found that the addition of this auxiliary generator does not increase the size of the building required even though the length of the unit is increased some 10 or 11 ft. This space would be necessary in the generator room for an ordinary turbine alternator but would not be used except when assembling or disassembling the generator. The auxiliary generator, therefore, merely utilizes waste space in the station.

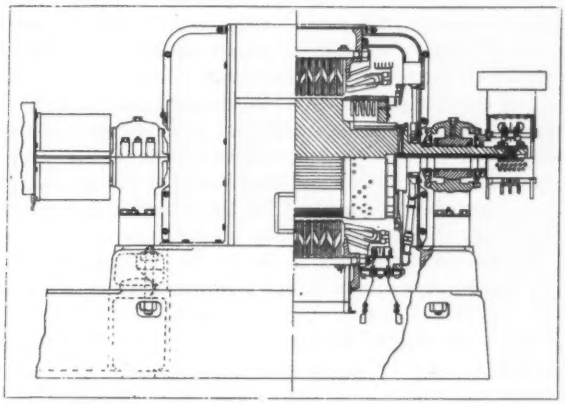


FIG. 3. ASSEMBLY VIEW OF A 2670-KV.A., 1800-R.P.M. AUXILIARY GENERATOR

The efficiency of supplying power from the main generator or auxiliary generator is about a stand-off. If power is taken from the main generator, it must be taken through a transformer. The electrical efficiency of a 35,000-kw. turbine alternator is about 97 per cent at full load and assuming 2 per cent loss in the transformer, we get an efficiency of about 95 per cent for the auxiliary power supply from the main generator.

An auxiliary generator, if used, supplies power direct to the auxiliary bus, and the efficiency of a 2000-kw. auxiliary generator is about 95 per cent so that there is practically no advantage either way as regards efficiency. The auxiliary generator increases the cost of the unit but at the same time adds to the total generating capacity. The principle advantage of the auxiliary generator seems to be the increased reliability of power supply for auxiliaries which is obtained by operating them on a separate electrical system, with the main bus available as an emergency supply in case of trouble on the auxiliary system. Figure 5 shows the connections being used for one of the first stations where auxiliary generators were installed.

It has been suggested by some engineers that the auxiliary generator should be a direct-current machine from which the excitation for the main unit may be taken

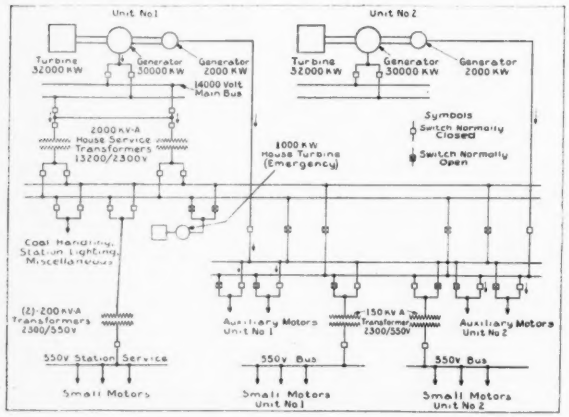


FIG. 5. TYPICAL UNIT POWER SUPPLY FOR STATION AUXILIARIES USING AUXILIARY GENERATORS

directly, and which will also drive the essential auxiliaries. Such a scheme has been adopted for new units used in Baltimore and two 20,000-kw. turbines have been built having 500-kw., 1800-r.p.m., 250-v. d.c. generators connected to the main units for supply of excitation, boiler feed, circulating water and condensate pumps.

The chief advantage in this scheme seems to be that the excitation problem is simplified, no additional exciter being required, and the use of direct current for pump motors make variable speed easily obtainable by use of d.c. motors with field control for boiler feed and circulating pumps.

Its limitations appear to be in the fact that such a high speed d.c. machine is not a conservative design and some engineers feel that it is not as dependable as an a.c. generator for similar service. Its commutation would no doubt be affected by any unbalance in the unit and maintenance will probably be higher than on an a.c. machine. If an emergency direct-current supply for the essential auxiliaries is to be provided, either motor generator sets must be installed taking power from the main bus or a battery must be provided. With the d.c. auxiliary generator providing excitation for the main generator, a Tirrill regulator could not be used on account of fluctuation in voltage supply to auxiliary motors.

Since the necessity for low-pressure steam from auxiliaries for feed-water heating has largely passed, due to stage bleeding of the main units, the use of a house turbine set must be justified on the basis of its necessity as a supply of electric power for auxiliaries, rather than for proper heat balance of the station.

The use of the house alternator was a distinct step in advance over the use of steam-driven auxiliaries, as it eliminated a large amount of steam piping and small turbines of comparatively lower economy and provided a flexible unit for the heat balance control of the station, the practice being to tie the auxiliary bus to the main bus through transformers and vary the load on the house turbine depending on the amount of steam required for feed-water heating. The present tendency in power plant design is to eliminate the house turbine set except as an emergency power supply for electrically-driven auxiliaries. There are several possible methods of operating such a unit. It may be operated continuously on the auxiliary bus, or kept as a stand-by unit for use only during emergency starting.

If power is normally supplied from the main units for driving auxiliaries, it is desirable to have at least one non-condensing house turbine for emergency starting in case of a complete station shut-down. Otherwise a main unit must be in operation in order to operate condenser and boiler feed pumps, whether the auxiliaries are supplied from the main or auxiliary generator driven from the main turbine.

To start a main turbine of large size non-condensing is considered difficult as well as rather risky, due to low power output, and large amount of expansion due to high temperature of exhaust shell. The use of a small non-condensing house turbine eliminates the necessity of starting a main unit non-condensing.

Where auxiliary generators are used on the main units there is no excuse for operating a house turbine continuously as there are already two sources of power available, and the house turbine should logically be used only for emergency starting. In case no auxiliary generators are used and auxiliaries are fed from main units, through transformers, it may be desirable to float house turbines continuously on the auxiliary bus so that in case of failure of power supply, the auxiliary bus can be cut off from the transformer, and auxiliary turbines can pick up the load

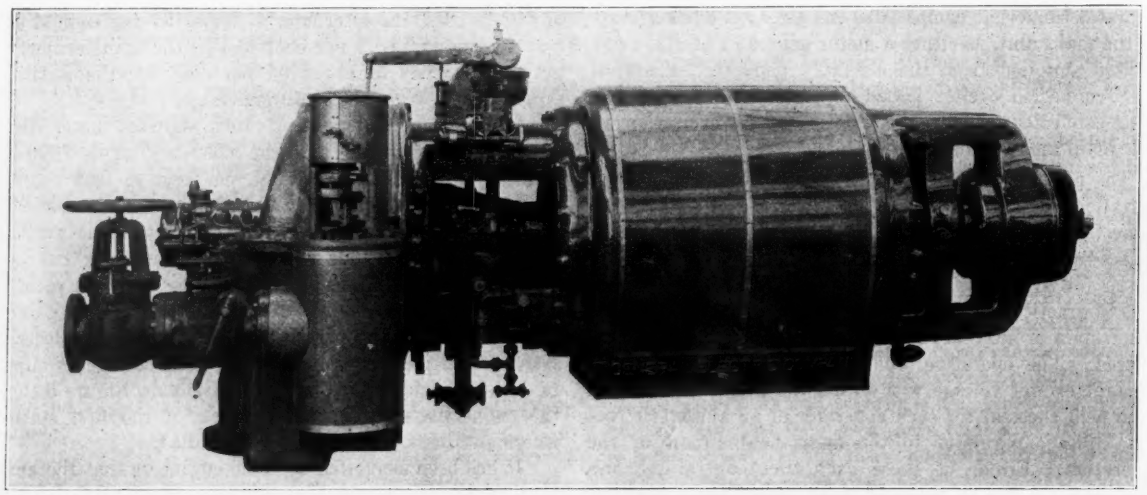


FIG. 4. A 1250-KW., 3600-R.P.M. NON-CONDENSING CURTIS STEAM TURBINE SET

without interrupting service to condenser and boiler feed pumps and motor-driven exciters.

This insurance to power supply must be paid for in losses in the house turbine and generator. Where such a unit is floated on the auxiliary bus, the generator, is usually operated as a condenser with full field excitation. This helps correct the power factor of the auxiliary load which is usually down around 0.5 or 0.6 power factor due to partially loaded induction motors. The turbine, if non-condensing, must be supplied with cooling steam, as the heat due to friction of the wheels with the gases in the turbine must be carried away by circulating a certain amount of steam through the turbine. Some condensing turbines will have enough packing steam to keep the wheels cool while others will require cooling steam. As an example, a 2000-kw., single-stage, 3600-r.p.m. Curtis turbine, designed to operate at 325 lb. gage, 295 deg. F. superheat, required the following amount of cooling steam when operating at no load.

Back Pressure	Pounds steam per hour
2 lb. gage (non-condensing)	6700
2 in. mercury absolute (condensing)	2800

The above includes friction and windage loss in the generator. It has been suggested that such a turbine be operated in a vacuum by use of a small pipe from the main condenser, and a relief valve provided for atmospheric exhaust when house turbine is loaded.

Since the house turbine is to be operated with load only during trouble or emergency conditions, its water rate is of no consequence. It should be as small and cheap as possible for a given rating and if it is to be floated on the line, its no load losses should be kept down to a minimum.

The required size of such a unit depends upon the scheme of operation, and the electrical layout of the auxiliary busses. If for emergency starting only, it need be only large enough to start and run the essential auxiliary motors for one main unit, for as soon as one unit is up to speed, it can carry the load of other auxiliaries. If the house turbine is to float on a bus section, it should be of suitable size to carry the auxiliaries normally operated from that bus section, which would probably be the principal auxiliaries for one or possibly two main units.

It has been the experience of several operating companies that if a complete station shut-down occurs in a large station, the load dropped on the other plants of the system is so great that the system voltage and frequency will drop considerably, and sometimes even cause a shut-down of the other stations. This means that it is impractical to depend on other stations to supply power for starting auxiliaries after a complete shut-down. It has taken 40 to 60 minutes to get a steam plant back in operation after such a shut-down in cases which have come to the writer's attention, where it was necessary either to start a main turbine non-condensing, or get power from outside.

This indicates the necessity for at least one non-condensing house turbine where auxiliaries are fed from the main bus.

Figure 6 shows a single-stage non-condensing turbine alternator set suitable for use as a house turbine. Such a unit as this can be started from cold and brought up to speed in about 10 min. for emergency starting.

In a subsequent article on the subject of auxiliary drives the question of a.c. versus d.c. power for auxiliaries will be taken up.

Operation of Transmission Systems

ABSTRACT OF A PAPER DELIVERED AT THE ILLINOIS GAS, ELECTRIC AND ELECTRIC RAILWAYS ASSOCIATIONS JOINT CONVENTION. BY JULIUS L. HECHT*

IN THE generation and distribution of electrical energy the advantages of our present widespread unified systems are many, both from the viewpoint of investment and operating costs and in the ample and better service obtained. It is needless here to discuss in detail the advantages and I, therefore, merely set down in tabular form some of the more important points with a few comments.

1. Larger stations are made possible, with the result that:

(a) Larger individual units can be used.

(b) Better operating efficiency is obtainable.

(c) Higher wages and consequently greater operating skill can be maintained.

(d) Investment per unit of capacity is lower.

2. The capacity of a number of stations can be pooled with the result that:

(a) Less total investment in reserve is required.

(b) Diversity between load and capacity required is improved, due to a greater variety of business.

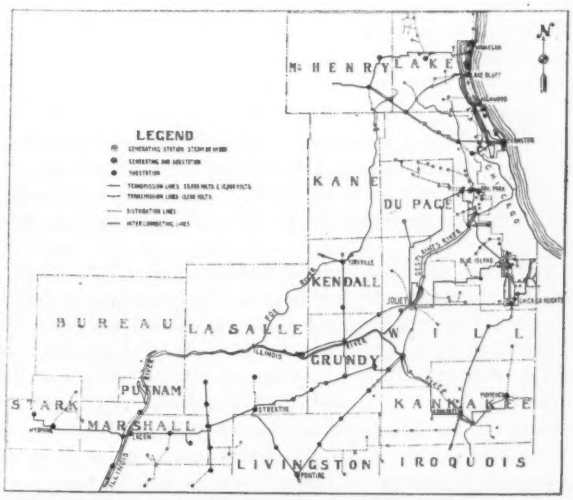
(c) The most efficient units can be operated at a better load factor. (It is assumed that developments in the art will continue for some time.)

3. The spreading of industries over a greater area is encouraged, with the result that:

(a) Better living and housing conditions can be had by employes.

(b) Service is made available to many small communities which could not otherwise be supplied at reasonable rates.

In considering the general subject of transmission lines, the following figures and facts are given as being of possible interest:



TRANSMISSION SYSTEM OF THE PUBLIC SERVICE CO. OF NORTHERN ILLINOIS

*Vice-President, Public Service Co. of Northern Illinois.

The Public Service Co. of Northern Illinois has taken over and shut down a total of 57 stations. In the year 1905, when the writer entered the service of the North Shore Electric Co., one of the principal predecessor companies of the Public Service Co. of Northern Illinois, the North Shore Electric Co. was operating 9 stations with an average fuel requirement of 11.7 lb. of coal per kw-hr. During the year 1924, the Public Service Co. of Northern Illinois sent out 454,899,765 kw-hr. at an average fuel requirement of 2.14 lb. per kw-hr., or a total of 486,882 T. of coal. Had it been possible to develop the business under the old condition of disconnected stations, on the basis of 1905 average fuel requirements, it would have necessitated the burning of 2,661,163 T. of coal. Furthermore, during 1924, 58 per cent, or 265,331,803 kw-hr., were produced in the Public Service Co.'s two most modern stations at Waukegan and Joliet on an average of 1.72 lb. of coal per kw-hr., which may be taken as an indicator of the performance to be hoped for with further development of the interconnecting of transmission systems.

Turning to the engineering and operating part of our subject, we find that there has been a similar rapid advancement along these lines. Since 1897, when the Commonwealth Edison Co. installed 9000-v. lines, operated initially at 4500-v., between their Harrison Street and 27th Street stations in order to shut down the former comparatively inefficient station, transmission system design has passed through various stages to the present type of large capacity, high voltage steel tower trunk lines interconnecting large stations and important load centers; and to the 12-kv. to 50-kv. lines commonly used for supplying substations and distribution centers. One of the more important steps in this development was the adoption of loop systems.

General types of construction have been standardized to a great extent but one very live issue is the value of a ground wire. There is a wide difference of opinion on this but from the Public Service Co.'s experience using lines both with and without ground wires, I am convinced that if ground wires are installed the operating hazard due to breaking must be avoided by first: installing a wire of a strength and durability at least equal to that of the conductors; second: the wire must be attached to the structure with equally flexible connections, especially on high voltage trunk lines with long spans; and third: the ground wire must be thoroughly grounded, which at times is impractical. When these three things are done the cost of the installation is such that it becomes doubtful whether or not ground wires can be justified.

Another question which is debatable is the protective value of lightning arresters on transmission lines operating at voltages in excess of 100,000, because the normal insulation of these lines is for voltages which are in the order of those usually found to be induced by lightning disturbances.

Increase of generating capacities back of the transmission system has required the installation of reactors and the development of large capacity switches capable of interrupting the enormous currents in cases of trouble. It is the opinion of many that the oil circuit breaker is the weak link in the chain today. The complexity and size of equipment for line terminals where the installation is indoors, has become not only a very considerable item of expense but also one of space.

This is especially true of the "phase separation" system which is used in some of the larger stations. In this connection the ironclad switchgear commonly used in England should receive more attention from American engineers.

There have been many interesting problems arising from the development of the present interconnected or loop system, such as the necessity for having selective relay action on the various switches throughout the loop, which brought about the induction type definite time element and directional relay for switch control and the problem of voltage regulation which has been met largely through regulation of the feeders at substations and distribution centers with induction type regulators. However, the voltage regulation on high voltage transmission systems makes it imperative that the power factor problem be solved by some means.

All of these improvements in design have been toward the end of dependable service. Continuity of service is the most important factor in good central station service from the customer's standpoint, especially with reference to industrial power. A certain variation in voltage may occur without seriously interfering with the customer's production, but when his service is interrupted there is more or less of a total loss in production without corresponding decrease of expenses. The Illinois Commerce Commission has fittingly recognized the value of continuity of service in the weight of 30 allotted to this factor, out of a total of 100 in arriving at their grades for service furnished by any utility company.

When unified systems were first built up the operating departments handled problems of operation as the emergencies arose without any special organization. As the system grew it became necessary to have one or more operating men on duty nights. Later developments led to load dispatching under direction of system operators or load dispatchers, on duty 24 hr. a day.

Training of System Operators

The training of these system operators has been and will continue to be a matter of vital importance. The responsibilities of the position are great and safety of both men and apparatus as well as the reliability of service require a man of good judgment and training. Men, preferably technical, temperamentally equipped must be picked and trained through serving in development positions such as switchboard and substation operators. These men must also have an objective to look to, as the types best able to operate a system are at the same time the types who are fundamentally able to advance. The organization of the operating department must provide that the system operators or load dispatchers must have absolute authority with reference to the operation of the system while on duty. In turn the system operators must be held responsible for seeing to it that the load is carried on the most efficient units and transmitted over the most efficient routes to the distribution centers; also, they must see that sufficient reserve capacity in boilers, turbo generators, and other equipment is available to meet emergencies.

In the operation of a large system it is necessary to have operators at various points without immediate supervision. This requires the establishing of very detailed routines, leaving as little as possible to the operator's judgment, especially as communication systems are liable to fail at the same time as troubles in the transmission system occur. The development of the carrier current and radio communication systems will be very beneficial to the com-

pany operating over a large area. Automatic distribution centers have improved service materially in communities which cannot support attended substations. Supervisory remote control of oil switches has also assisted along this line and remote control by carrier current seems promising if the matter of prohibitive cost can be overcome.

Inspection of Lines

Regular patrolling of lines, use of hot wire tools where lines cannot be taken out of service without interruptions which would seriously inconvenience customers; frequent sectionalizing points in all except very short lines, are all considered a necessary part in the operation of our transmission system.

No paper on a transmission system would be complete without reference to "super-power." It is a much abused term and while we recognize this we can at the same time appreciate the tremendous advantages to be gained through development of super-power interconnections with auxiliary network of transmission lines. In fact, we today stand at the point where the lower voltage (12,000 to 35,000 v.) transmission systems must be considered as local interconnections and feeders and the so-called superpower systems of voltages in the vicinity of 100,000 must be considered a necessity, since the production and distribution of electrical energy is no longer a local matter, but must be viewed as a problem covering great areas, so that a suitable economic pooling and maximum production of energy can be carried on.

Industry Wastes Power

Power Waste May Be Equal to the Profits of the Industry. Most of It Can Be Eliminated by Careful, Systematic Inspection

IF HALF the power paid for by an industrial plant is wasted through leaks, friction and carelessness, why struggle for an extra one or half of one per cent gain in efficiency in the power plant? If the big loss is there, why not go out to reduce that? Many plant owners and managers of industries regard the power plant and its cost as a necessary evil and a non-productive expense. Yet it is that very power plant which makes possible a production per employe of five to twenty times what could be produced without power. But, granting that power, because of its multiplying the effectiveness of workers, is the biggest factor in production, it becomes more important that as much of it as possible be utilized in increasing production.

While power is a vital productive agent in every industry, its cost is estimated to average about only 10 per cent of the cost of the product, which is one reason why power waste has not been given close attention by works managers. Yet, if half this can be saved, it will reduce the cost of products 5 per cent, which may often mean the difference between a profit and a loss in a close market.

What is the extent to which power is used? Recent investigations disclose that some 30,000,000 hp. is used in industrial establishments of which 20,000,000 hp. is generated in individual plants, 17,000,000 hp. of this being steam plants. The amount varies in different industries. For some industries the power used per employe and its cost per year are as follows: Cotton goods, 4 hp.; lumber, 5 hp. and $338; chemical industries, 11 hp. and $398; iron and steel industries, 42 hp. and $423; cement making, 18 hp.; food products, $313; paper and printing, $382; non-ferrous metals, $242; store, glass and clay, $440.

On this basis, a lumber mill employing 200 workers will use 1000 hp. at a yearly cost of $67,600 and half this saved would add $33,800 to the profits. In a steel plant employing 1000 men, half of them on machines, the power used would be 21,000 hp. and the yearly cost $423,000. Even if only 20 per cent of this could be saved, it would amount to $84,600 which should be a welcome addition to dividends. Even for a cotton mill with 500 workers, the power used would be 2000 hp., which, at $40 per hp.-yr., would be $80,000 and a saving of, say, 30 per cent would give $24,000 to the good.

What are the steps to make these savings? Obviously, the first thing is to know your power costs and where the power is going. Not all plants waste 50 per cent of the power generated. Some waste only 10 to 20 per cent; these are on the preferred list. Some waste more than 50 per cent; they are on the sick list, often with a malady dangerous to owners and employes.

Cost of generating power ought to be known, as a total and in details of fuel, water, labor, supplies, maintenance, and overhead, which includes interest, taxes, depreciation and management. Next the power, heat and light consumption of departments should be known and they should be charged for what they use, the same as if purchased from an outside company. This requires metering of steam, water and current and for power mechanically transmitted a careful record and estimate. Some trouble but necessary if the manager is to find where the power goes. Here, also, each department should stand the cost of labor, supplies and depreciation for its power equipment. It is essential to know what power cost each department causes.

While establishing these records, it is possible to hunt for steam leaks, water waste, idle motors running, lights burned uselessly, process steam blown to atmosphere. By test of power to machines and shafting when idle and when carrying load, the power actually used in production can be compared with that absorbed in friction.

As a byproduct, it will often be found that exhaust steam can be used in place of live steam at a worth while saving and, not infrequently, improved processes will be devised which will result in a saving of steam, power and labor.

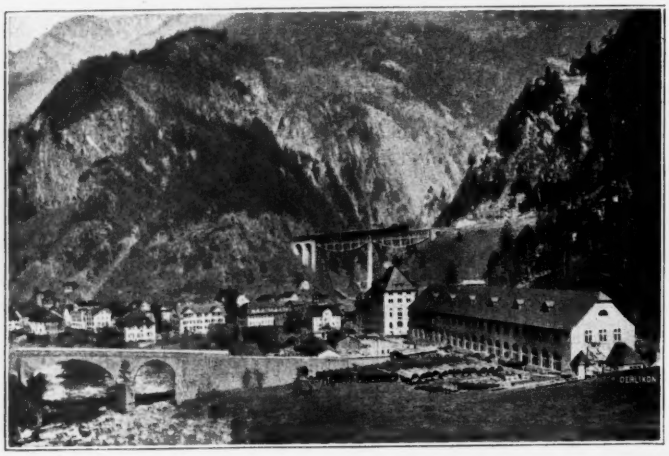
Like anything worth while, reducing power waste calls for work and perseverance, but it can be made to yield large returns.

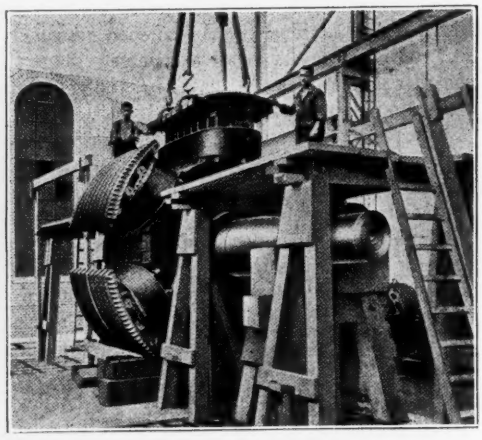
As an indication of the extension of steam generation, leading stoker manufacturers report sales during 1924 of stoker capacity to serve 5,142,790 sq. ft. of heating surface, about 514,279 boiler horsepower. Of these, the largest boiler unit is a 3275 hp. cross-drum B. & W. at the Allegheny County steam heating plant in Pittsburgh, Pa. The next largest units are four boilers of 3060 hp. each in the Lake Shore Station of the Cleveland (Ohio) Electric Illuminating Co. These big units, as well as enough more to make up 6,195,360 sq. ft. of heating surface, 619,536 boiler horsepower, were equipped with steam flow and air flow Bailey boiler meters, which gives an indication of the advance in standards of operation. It is interesting to note, in contrast, that the smallest boiler equipped with these meters during 1924 was a 100-hp. unit at the U. S. Naval Station, Key West, Fla.

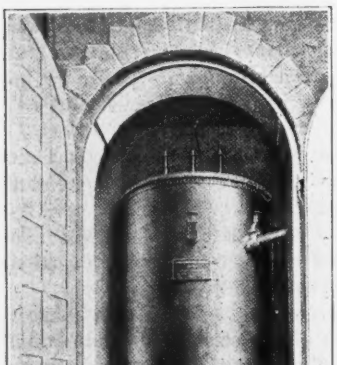
Swiss Railways Utilize Water Power

SOME DETAILS OF PLANTS AT AMSTEG AND RITOM WHICH SUPPLEMENT EACH OTHER. BY CHARLES J. WEBB

SEVERAL interesting features are to be found in these two plants, recently put into service by the Swiss Federal State Railway Authorities at either end of the St. Gotthard tunnel. The one at Amsteg has little storage capacity for water and is used during the summer while the water is coming down from the melting snows. The other at Ritom has two large storage lakes which are used to hold the water, which comes from the snows during the summer, and to supply power during the winter season when the stream which serves the Amsteg plant is greatly diminished. Both feed into the same system and may be run in parallel.







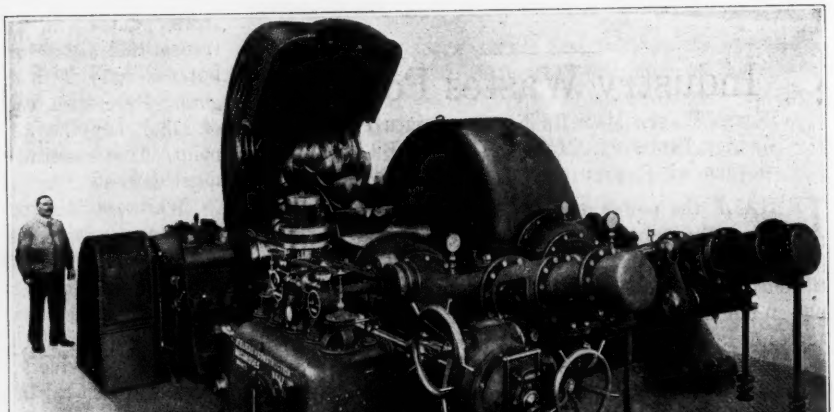


FIG. 1. POWER HOUSE AT AMSTEG FURNISHES CURRENT FOR RAILWAY SYSTEM. FIG. 2. 60,000 TO 15,000-V. TRANSFORMER IS MOUNTED FOR ROLLING OUT UPON TRANSFER TRUCK, CAPACITY, 5000 KV.A. FIG. 3. 10,000-V. ALTERNATOR HAS SIX-POLE REVOLVING-FIELD ROTOR. FIG. 4. TWO PELTON WHEELS, MOUNTED ON ONE SHAFT, DEVELOP 14,300 HP. AT 902 FT. HEAD

Water supply for this station comes from the River Reuss, the dam being at Pfaffensprung whence the water is conveyed under pressure to a water tower through a tunnel 4⅝ mi. long and 70 sq. ft. section. This water tower, situated above the village of Amsteg is cut in the solid rock, is 16.4 ft. diameter and 98.5 ft. deep. At the lower end it is connected to a gallery 753 sq. ft. in section and 360 ft. long and at the upper end to a discharge shaft 236 sq. ft. section and 262 ft. long. From the water tower three steel conduits, each 1476 ft. long, 5.9 ft. diameter at the upper end and 5.25 ft. diameter at the lower end, lead to the station, each pipe being intended to feed two 14,300-hp. turbines.

So far, only five units have been installed, turbines of the Pelton type, built by the Societe des Ateliers de Constructions Mecaniques of Vevey coupled direct to Oerlikon alternators but work is well in hand for the construction of the sixth unit. Turbines are designed to work under a head of 902 ft. and delivery of 167.6 cu. ft. per sec., the speed being 333 1/3 r.p.m.

When the station was first projected, two plans were considered, one for the use of single-rotor turbines operated by two jets, the other for twin wheels on the same shaft, each operated by a single jet. Decision was in favor of the latter as having more readily accessible injectors and a better water flow. Linear velocity of the buckets is 37.5 per cent that of the jet for a maximum output of 15,000 hp., which is a high value for turbines of this type. Diameter of the wheels is 6 ft. 1 in. and of the jets about 8.4 in., claimed to be the largest jets so far in use in Europe. Each wheel is enclosed in a separate casing, two being mounted on a common cast-iron base which is located on steel plates. These plates are used to protect the masonry of the discharge canal from the action of any water projected from the wheel outlet and from the jets when those are suddenly deflected.

Details of Wheels

Each wheel has 20 cast-steel blades, polished on their inner faces. As each blade receives no less than 333 impulses a minute of 17.5 T. each, special attention was given to provide secure attachment to the disk by means of two special rings bolted to the hub. This also makes it possible to dismantle the blades without disturbing the disk. Each of the two cast-steel injectors carries a tuyere of the same material with a bronze nozzle which can be easily renewed. A needle valve in the center of the tuyere permits of adjusting the water supply to the wheels in accordance with the load on the generators. These needle valves are screwed to rods which carry, at their outer ends, the adjusting pistons of the servo-motors. Thrust of the water on the needle valves is partially balanced by powerful steel springs, mounted within the servo-motors, to facilitate hand regulation.

Although the tendency of the needle valves, in all their positions, is to close the nozzles, any sudden closing is rendered impossible by means of a special arrangement of the servo-motors to act as oil brakes on the valves. A second system of controlling the speed of the wheels is furnished by a deflector screen surrounding the jet, by means of which the water can be instantly diverted from the blades of the wheel in case of a sudden decrease of load. This deflection screen is operated by an independent servo-motor. To prevent interruption of operation in case of accident to the double-action regulator, a device has been incorporated by means of which hand regulation is automatically brought into action in such case. Also, a governor is provided which automatically diverts the water of the jet whenever the speed of the wheel increases 20 per cent above normal.

Construction of Generators

Six-pole alternators are used with rotating field and stationary armature, self-ventilating and totally enclosed. The stator is in four parts with removable feet so that the whole frame can be revolved, if desired, for inspection or erection. The rotor is of steel plates pressed onto the hub with extensions to support the pole pieces, which are laminated and provided with damping windings. Main field windings are of copper strip, wound on edge. The shaft, which is hollow and with forged coupling, has two ring-lubricated bearings supplied with oil from a pressure pump, the oil being cooled by water circulation.

Weight of the rotor is 100 T. and of the entire machine with exciter and foundation plate 250 T. Generation and transmission are single phase, the generators giving 15,000 v ., which is stepped up to 60,000 v. by transformers having capacities of 10,000 and 5000 kv.a. These are core type, immersed in oil which is brought out of the tank for cooling and which can also be treated for contained water and air by a vacuum process. Each transformer has its own cooling outfit in which the circulation of oil and water is controlled by special apparatus but the plant for purification of the oil is common to all transformers. Each 10,000-kv.a. transformer, with its oil, weighs about 50 T.

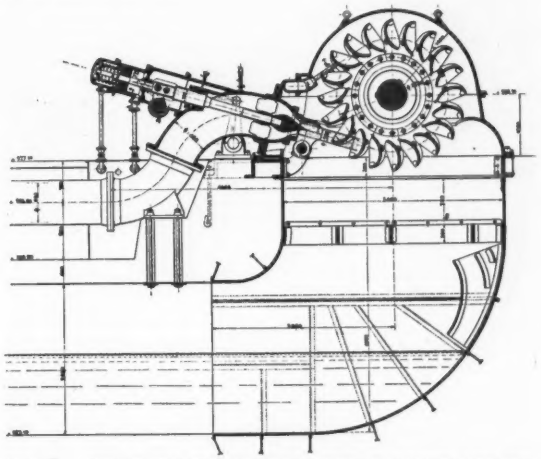


FIG. 5. JET IS CONTROLLED BY NEEDLE VALVE AND BY DEFLECTION SCREEN

To supply current for station use, voltage is stepped down to 440 v. by 500 and 300-kv.a. transformers and by motor-generator sets with outputs of 100, 50 and 20 kw. to supply the direct current needed.

Ritom Station

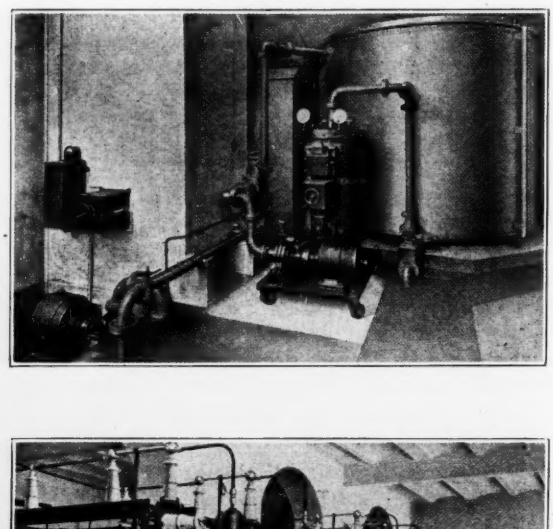
At this development, provision is made for the storage of 917,800,000 cu. ft. of water in Lake Ritom and a feeder lake above. Level of Lake Ritom was raised 22 ft. by the dam, so that the head on the plant is 2700 ft. From the lake a tunnel 2850 ft. long leads to the forebay above the plant, the grade in the tunnel being 7 per cent. Control valves, operated by remote-controlled motors from the plant, admit water from the forebay to the pipes which lead down to the plant.

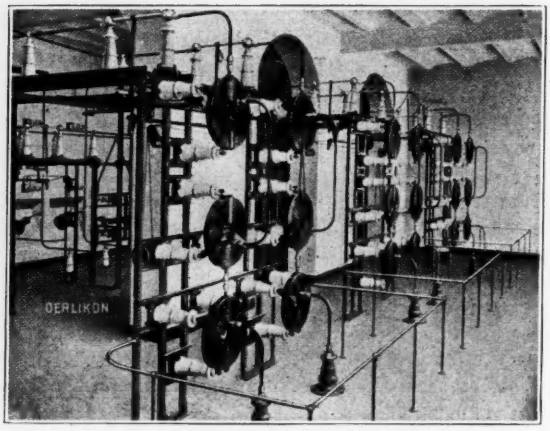
It was intended to install one pipe line for each two wheels but, as it was impossible to get steel of the thickness required for the lower ends of the pipes during the war, the plan was changed and the two pipes branched to four, one for each wheel installed, at about half way down, thus giving smaller pipes at the lower end and permitting the use of thinner plates. At the upper end, the two pipes are 43¼ in. diameter inside, which is reduced to 33½ in. at the point where the Y's are inserted. The lower pipes are 25.6 in. diameter throughout their length. Sections are joined by riveted bump joints, which is the first use of this type for such high heads but has proved entirely satisfactory. When the remaining two wheels of the planned

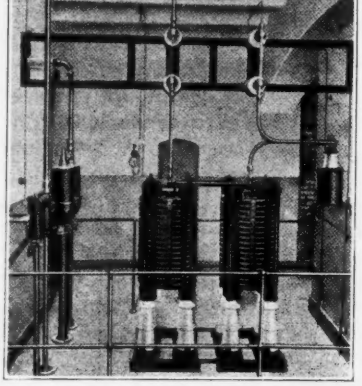
installation are installed, a third pipe line will be laid, probably as a single line from top to plant.

Four generating units are now in use, two more being planned. They are Pelton wheels with needle nozzle control similar to those at the Amsteg plant, operating under head of 2700 ft. at 333 1/3 r.p.m. and giving output of 12,200 hp. Generators deliver 9000 kv.a. at 15,000 v. and 16 2/3 cycles, single-phase.

In order to reduce insulation problems and damage from grounds, the central point of the transformers is grounded so that the maximum voltage from ground to line is 30,000. All high tension gear, bus bars, switches, choke coils, etc. are mounted on insulators which are fixed to their bases by a simple clamp and have a metallic cap into which the switch contacts and conductor supports are







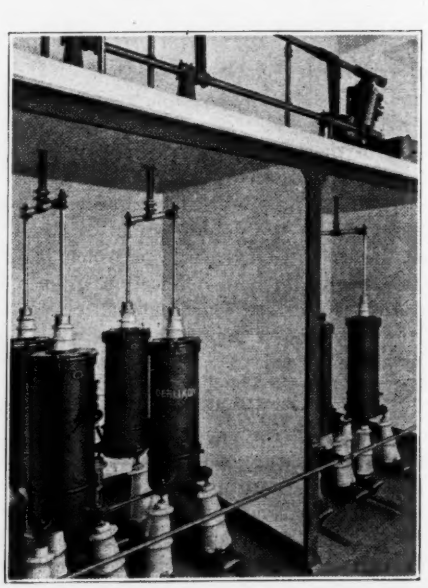


FIG. 6. RITOM PLANT OPERATES UNDER 2700-FT. HEAD

FIG. 7. TRANSFORMER OIL IS DEHYDRATED AND DEAERATED IN SPECIAL APPARATUS

FIG. 8. FLAT SPIRAL CHOKE COILS ARE MOUNTED ON INSULATORS

FIG. 9. NEUTRAL POINT OF 60,000-V. TRANSFORMERS IS EARTHED BY THIS EQUIPMENT

FIG. 10. HIGH-TENSION SWITCHES ARE MOUNTED IN CELLS, SUPPORTED ON THREE INSULATORS EACH AND BREAK THE CURRENT AT FOUR ISOLATED POINTS IN THE CIRCUIT

screwed. To avoid leakage, switch contacts are rounded off or statically protected by covers and all live parts of the high-tension gear are polished and nickeled. Oil switches, which are proportioned to take care of a short-circuit load of 250,000 kw., have two sets of four single-pole units in series so that the circuit is broken at four different places between which there is no electrical connection. Contacts are made by a plunger sliding into tubes which are split to ensure a firm contact. Each switch unit is supported by three insulators mounted on a common base fitted with rollers. Plungers are attached to cross arms which, in turn, are connected to operating levers by tubes of insulating material. The whole switch operating gear is mounted on the roof of the oil switch cells.

Three choke coils are connected in series with each outgoing conductor. These coils are of spiral form, mounted on three insulators which are attached to the wall or to iron framework. Horn lightning arresters are used with gaps adjustable from 1 in. to 5 in. by sliding the horns in and out of the holders. In series with each arrester is a liquid resistance consisting of a column of water in a tube of insulating material.

Isolating switches are mounted on insulators and are operated from a horizontal shaft by means of a rod of insulating material, the shaft being actuated by a rope from a hand wheel below. Connections are made by copper tube about 1¼ in. diameter.

Transmission is at 60,000 v., single-phase, the substations stepping down to 15,000 v. for supply to the feeders to the railway system.

Offset Bend Factoring

By Dwight Gerber

IN THE illustration is outlined a problem, the like of which there are many handed out by people buying pipe. The shop man must have some ready means of determining a suitable and proper radius, length of pipe in bends and the distance tangent point to tangent point of the curve.

Most of the methods used in handling this sort of problem consist of choosing a radius of bend equal to a certain number of pipe diameters and with it determine the angle measure. It is this angle when given in degrees and minutes that presents trouble to the shop man in laying off the curve.

What is needed is a method of finding an even angle measure for the central angle, preferably some division of 90 deg., owing to the ease with which the arc length may be found and to throw the necessary variation into the radius length of the bend. A slight change in the radius, either more or less than the customary five or six-pipe diameter, is permissible.

The table under the sketch in the illustration is arranged to facilitate such a trial method.

In column 5 is given a value for the natural function of sine and cosine of the angles given in columns No. 1 and No. 2 respectively.

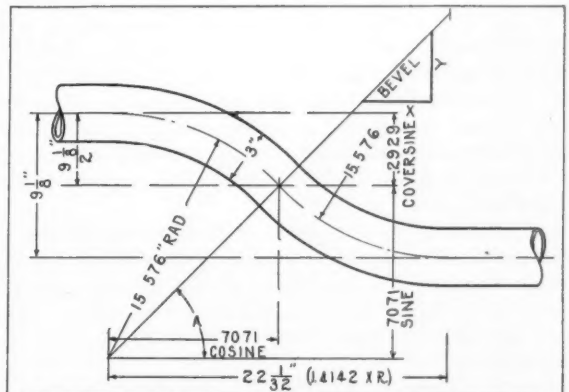
In column 6 is given the natural function of the coversine of angle A termed the central angle, which in a balanced offset bend would be equal to just one half of the amount of the offset.

In columns 3 and 4 are given the legs of a right triangle by means of which an angle may be laid off without a protractor.

In column 7 are given constants for the angles shown in column No. 1 which multiplied by the radius will give the arc length.

When one has a table of 90 deg. arc lengths for varying radii, this may be found in any handbook; the arc length may be provided for any of the angles given in column 1 of the table.

The amount of variation that will be thrown into the radius of the bend by selecting an even angle measure will in no case be excessive.



NATURAL FUNCTIONS-BEVELS AND ARC CONSTANTS

SINE-A	COSINE-A	X-BEVELS	Y	FUNCTION	COVERSINE	CONSTANT
15°	75°	12	3 7/32	.2588	.7412	.2618
20°	70°	12	4 3/8	.3420	.6580	.3491
25°	65°	12	5 5/8	.4226	.5774	.4363
30°	60°	12	6 15/16	.5000	.5000	.5236
35°	55°	12	8 13/32	.5736	.4264	.6109
40°	50°	12	10 3/32	.6428	.3572	.6981
45°	45°	12	12	.7071	.2929	.7854
50°	40°	10 3/32	12	.7660	.2340	.8727
55°	35°	8 13/32	12	.8192	.1808	.9599
60°	30°	6 15/16	12	.8660	.1340	1.0472
65°	25°	5 5/8	12	.9063	.0937	1.1345
70°	20°	4 3/8	12	.9397	.0603	1.2217
75°	15°	3 7/32	12	.9659	.0341	1.3090

THIS METHOD OF LAYING OUT OFFSET BENDS DOES NOT REQUIRE A PROTRACTOR.

Selective method: Divide one half of the offset by the assumed radius taken as 5 pipe diameters or 15, thus

$$4\tfrac{9}{16} \div 15 = \frac{4.5625}{15} = 0.304$$

the nearest value to be found in natural functions coversine given in column 6 is 2929 for 45 deg. and by dividing 4.5625 by this function we obtain a new radius length that will fulfill the condition, namely, 15.57 in.

That the length of arc will be equal to that of one square bend will be obvious.

A little practice with the method will make apparent the proper method of handling problems having the radii unequal.

The primary purpose of this last method is to accomplish the selection of the nearest even measure (multiple) angle that will answer and to adjust the radius length so that the difficulties presented to the shop man will be reduced to a minimum.

Power Plant Developments Abroad

IN A GERMAN publication (Die Wärme, Jan. 9, 1925), a new type of boiler for high-speed steam production is described. This boiler has no water chamber and while the apparatus is designed particularly for marine work, the principles involved are claimed to be of such importance as to render them applicable to other purposes. This refers in particular to the elimination of the water chamber in the boiler, which possesses many advantages.

This idea is not new in itself, but many disadvantages are found in boilers which do not have a water chamber. The new type of boiler consists of individual coils of pipe to which water inlet and steam outlet pipes are connected. Water is introduced through a common feed pipe just as in a regular boiler. From this pipe the water enters the hottest part of the pipe coils, being sprayed into them. Atomization takes place not through pressure, but through formation of steam itself. Details of dimensions of the boiler are given.

Application has been made of the flotation process to the preparation of coal, according to a German source, which describes the limitations of the process. Several methods of drying the concentrates are described. Both coal and coke treatments are discussed (Vereins Deuts. Eisenhütt).

Cost of steam production in a power plant was recently measured by determining the specific thermal efficiency of the operation. A detailed description of the method is obtained from German sources. The graphical representation of how to determine the amount of heat in the steam or converted into the form of steam from the thermal value of a fuel is first described. Then from that is found the consumption of coal required and from that the cost of fuel, giving finally the cost of steam (Braunkohle, 1924, No. 34).

In a recent paper read before the Institute of Mechanical Engineers in England steam extraction or pass-out system was discussed. This paper contained an outline of a method for obtaining steam consumption curves for the pass-out turbine. It also described how the main admission valve and the low pressure or pass through valves must operate to fulfill the requirements of the pass-out turbine under actual running conditions. It discussed as well types of central gear (Engineering, December, 1924).

A recent French article on the use of powdered coal in firing boilers, discussed mainly from the economic standpoint, contained the following conclusions:

1. The use of pulverized carbon becomes more advantageous as the coal price becomes higher, quality remaining the same, which indicates that this practice is more advantageous for the consumer of the coal than for the producer.

2. It is less interesting with coal itself as when real coals are used, other methods of combustion yield approximately the same efficient results.

3. It is of special advantage in using inferior coals which cannot be so well utilized by other methods of combustion, applying particularly to coal containing from 20 to 35 per cent of ash.

4. It does not appear to be very advantageous with coal containing considerable proportions of ash (La Genie Civil, January 3, 1925).

For keeping the heating surfaces of boilers and economizers clean, a system which seems to be productive of good results is the pneumatic method of flue dust removal. The plant that is required for removing the flue dust by pneumatic means consists of first a vacuum pump or exhauster, an intercepter for intercepting any dust which may pass over from the main container, the dust container which holds the collected dust, the dust main pipe from the boiler flues to the container and appliances at the boiler flues for facilitating the sucking up of the dust.

This system may be applied in two ways: one, by the installation of pneumatic suction nozzles at different parts of the boiler plant; two, by using hand nozzles attached to a flexible hose pipe when it is necessary to enter the flues. The above plant is alike in both cases with the exception of the nozzle arrangements (Engineering & Boiler House Review, January, 1925).

An investigation on high pressure steam and back pressure working showed that increasing the initial pressure about 30 atmospheres results in comparatively small saving of heat when condensing engines are concerned. Best overall results are likely to be obtained by keeping within this pressure limit and devoting attention to the general efficiency of boilers and engines and particularly to heating the feed water to as high a temperature as practicable. In back pressure engines, exhausting to heating systems, the saving of heat (compared with the condensing engine) increases with the initial pressure of the steam and in a greater ratio the higher the back pressure (V. D. I. 1924-1009).

Leland Stanford to Have High Voltage Set

SO THAT IT can solve the problems of high voltage transmission well in advance of actual requirements, Leland Stanford University of Palo Alto, Calif., has ordered a 2,000,000-v. testing outfit from the General Electric Co. This set will operate at the highest voltage ever produced at commercial frequency, that is, at 60 cycles. This voltage will jump a spark gap formed by two needles spaced about 17 ft. apart.

California is second only to the state of Washington in the amount of water power resources within its boundaries. Of a total of 7,800,000 hp., 1,600,000 hp. are within 200 mi. of San Francisco, and this will be fully developed and utilized within ten years. Further development will need to be done with rivers 400 and 700 mi. from the district. For this, much higher transmission voltages or improved transmission methods will be required.

Professor Harris J. Ryan, past-president of the American Institute of Electrical Engineers and an authority on high tension phenomena, will in the future devote his entire time to research activities in this high voltage field. The new apparatus will be located in a special laboratory and there will be a large plot of ground for the construction of an experimental transmission line.

FROM 10 TO 40 per cent of the heat supplied to the average steam system is lost, due to radiation. Radiation losses are preventable to a large degree and may be minimized by the installation of the proper and adequate heat insulation.

Traps Must Be Properly Installed

MOST DIFFICULTIES ENCOUNTERED IN THE CARE AND OPERATION OF TRAPS ARE DUE TO CONDITIONS OUTSIDE THE TRAP. BY H. A. JAHNKE

OWNERS OF power plants at times decide to install tilting traps or some other type for boiler feeding and other purposes, to take the place of pumps, but after the traps are in service for a short time they find that they have much trouble with them. Generally the traps are condemned and replaced by pumps again at the first opportunity.

I have found that nine times out of ten the trouble does not lie in the traps but is mostly due to poor piping arrangements, traps being located incorrectly or the proper size or type not being used.

One mistake often made when installing a trap for boiler feeding is that the steam supply to the trap is connected in to any of the steam lines that may be most convenient. Then when the trap is placed in service it may fail to furnish sufficient water to the boiler or boilers. To give satisfactory service for boiler feeding, a trap must receive full boiler pressure; however, if the steam supply is taken from a steam line or steam header that also furnishes steam for other purposes, the trap may not get full pressure as it is not always maintained in a steam line with a number of outlets. The best practice in such a case is to drill and tap the boiler shell for a connection, preferably near the rear head on a return tubular boiler as shown in Fig. 1. In this way the trap will get full boiler pressure regardless of what steam may be taken from the main steam header or any other line connected into the boiler.

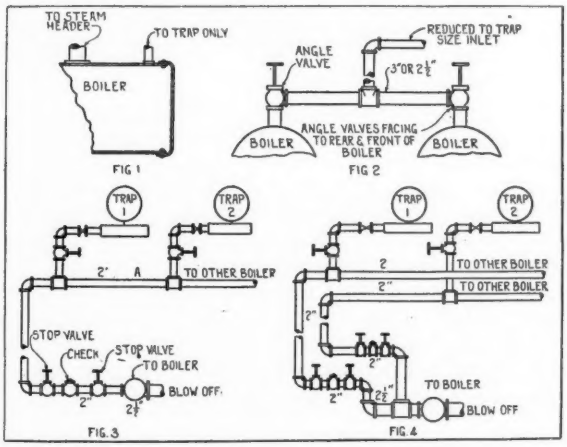


FIG. 1. DIRECT BOILER CONNECTION GIVES FULL PRESSURE ON TRAP

FIG. 2. SEPARATE STEAM HEADER FOR TRAPS SUPPLYING GROUP OF BOILERS

FIG. 3. POOR DISCHARGE CONNECTIONS THAT WILL CAUSE BACK PRESSURE IN A

FIG. 4. CORRECT DISCHARGE CONNECTIONS FOR TWO OR MORE TRAPS

When a number of boilers are supplied with water by steam traps it is good practice to arrange an individual steam header for the traps as shown in Fig. 2. By this arrangement, the traps will receive full boiler pressure no matter which boiler is out of service. When arranging a steam header for traps, pipes one or two sizes larger than the steam inlet of the trap should be used.

Often it is desirable or necessary to install two traps to furnish sufficient water to the boiler or boilers and the mistake is made of arranging the discharge from the traps to the boilers as shown in Fig. 3. In this system, if both traps discharge at the same time, they will cause back pressure in the main discharge pipe A leading to the boilers, hence the traps are unable to empty themselves as quickly as they should. A much better plan is to run an individual discharge pipe directly from each trap to the feed water inlet of the boiler as shown in Fig. 4. In this system no back pressure will be created in case both traps discharge at the same time.

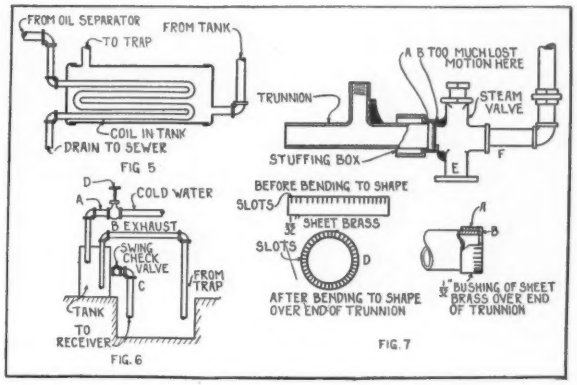


FIG. 5. SEPARATOR DRAINS HEAT FEED WATER

FIG. 6. TANK AIDS LIFTING TRAP OPERATION

FIG. 7. EMERGENCY BUSHING FOR PACKING TRAP TRUNNION

We may find that a trap for boiler feeding fails to furnish sufficient water to the boiler with the water supply valve wide open. When the trap was bought it was probably figured to be of the right capacity, hence there may be another cause for the trouble. In one case of this kind, it was found that the water pressure of the system was not sufficient to fill the trap tank quickly enough. As the water pressure could not be increased in this instance, the trouble was overcome in another way. There was a lifting trap in the plant that forced the water of condensation from the heating and other steam-using equipment into the boiler feed trap. A water connection was made from the hot water tanks to the lifting trap, a valve was placed in this water line to the trap in the boiler room, then whenever the feed trap was unable to furnish sufficient water, the valve in the water line was opened a little and make-up water ran into the lifting trap. This would force the water into the feed-trap tank quicker, hence the latter would act faster.

Pipes leading to and from the boiler from the trap should not leak at any of the joints. In some installations unions that require gaskets are used in the pipe connections. If these gaskets are of rubber, there is danger of the unions leaking because of the vibration in the pipe connections when the trap goes into the dumping or filling position. I have found that unions of the ground joint type give better service on this work than those using a gasket.

Increasing Temperature of Feed Water

If there is an oil separator in the engine exhaust line, the drain from this separator may contain considerable steam at times, which goes to waste in the sewer. Good use can be made of this steam and hot water by installing a heating tank with steam coils located as shown in Fig. 5. Then, by connecting the drain from the separator to this coil and passing the feed water through this tank, as shown, before it goes into the feed-water heater, the feed-water temperature will be increased considerably.

Trap Troubles and Remedy

In one instance I had a lifting tilting trap located at a building some distance from the power plant. This trap, located in a pit, received all the condensation from a receiver into which all the returns from the heating system and other steam using apparatus discharged. From this point the lifting trap discharged into a receiver located in the boiler room, then into the boiler-feed traps.

At first the exhaust discharged into the receiver of the lifting trap but I found that the trap operated too slowly,

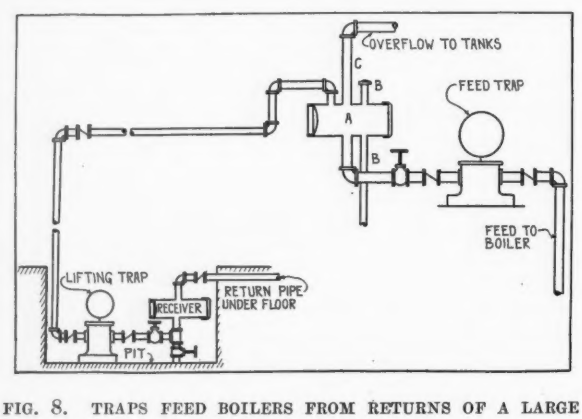


FIG. 8. TRAPS FEED BOILERS FROM RETURNS OF A LARGE BUILDING

on account of back pressure in the tank. As I could not connect the exhaust into the heating system or a hot-water tank, I placed a small iron tank next to the edge of the pit, as shown in Fig. 6, then connected a cold water line from the city main into the tank, as shown at A; next I connected the exhaust into the tank, as shown at B, with a pipe C from the tank to the condensation receiver.

This system works in the following way—a small stream of cold water runs into the tank through pipe A and, as the trap discharges the exhaust into the tank through pipe B, the cold water condenses the steam quickly, thereby removing the pressure from the trap tank. The water from the tank runs into the receiver, then to the lifting trap. With this system but little make-up water is necessary in the boiler feed trap at the power plant, as the water running into the tank at the lifting trap makes up for this.

When a tilting trap is not set level, it is likely to give much trouble, because it is impossible to adjust the weight so the proper amount of water runs into the trap tank to bring it into the discharging position; the result is that too much water runs into the trap, then, when the trap goes into the dumping position, there is but little space left in the tank, hence there is a water hammer in the tank.

Where that part of the trunnion which goes into the stuffing box is worn badly it causes the trunnion to lift when the trap returns to the filling position; this, of course, ruins the packing in a short time. I discovered this condition on one of my traps, as in Fig. 7. Since the trunnion was worn at 2 points, as shown in Fig. 7 at AB, the packing would not hold. As I did not have on hand a new trunnion nor the part containing the stuffing box I made a temporary repair in the following way.

First, I had the bottom of the stuffing box and the end of trunnion faced up. I then made a thimble of $\frac{1}{32}$ in. sheet brass, shaping this thimble to fit over the worn part of the trunnion at A and over the end at B as in Fig. 7. I had to cut notches into the piece of sheet brass first as shown at C, then bend it over the end of the trunnion as shown at D. The thimble was slipped over the trunnion and all parts put together; after the trap was in operation there was no movement of the trunnion and no further trouble with the packing. The thimble was put on about 6 months ago and so far there is no sign of it giving out. Of course, a new trunnion is in stock by this time.

Failure to Operate Told by Increase in Make-up

At one time I noticed that we were losing water of condensation at some point of the heating system; at first I was under the impression that some of the return pipes under the cement floor in the building had sprung a leak, because we needed much more make-up water than usual. In looking for the trouble I finally discovered that there was no leak in any of the pipes but that the trap taking care of the condensation sometimes failed to operate. That is, it would not go into the dumping position, with the result that the trap tank would fill with water until it reached the outlet of the interior steam pipe in the trap tank, when the water would run through this pipe into the vent valve and then to waste into the sewer.

Typical Layout of Large System

It may be of interest and benefit to some readers to show how the returns from the heating system and other steam equipment of a new building some distance from our power plant, are returned to the boilers by means of traps. All returns pipes are run under the cement floor and connected into a condensation receiver which is in a pit together with a lifting tilting trap as shown in Fig. 8. The discharge pipe from this lifting trap is run up to the ceiling of the new building—then along the ceiling of the old building into the boiler plant where another receiver is located about eight feet above the boilers, as shown at A. Into this receiver the discharge pipe from lifting trap is connected; another pipe, connected into the bottom of the receiver, leads the condensation to the boiler feed traps which are three or four feet below the receiver, while the feed traps are about five feet above the boiler water line. The make-up water is also run into this receiver, as shown at B. The discharge pipe from the lifting trap in the distant building to the receiver in the boiler plant is $1\frac{1}{2}$ in. and about 300 ft. long. The system has been in service for one year without any trouble. Of course where the discharge pipe from a lifting trap to the boiler plant is very long, as in my case, the pipe must be covered.

All the return pipe from the steam-using apparatus systems was laid and connected into the receiver before the

floor was put in, while the inlets were located about where it was thought the steam-using apparatus would be placed. Also a number of inlets were located at different parts of the building for future use. This I consider good practice as it will not be necessary to tear up the floor if other return inlets are needed.

All under-floor return pipes were placed in thimbles made of old pipe a size or two larger than the return pipe.

Defective Apparatus Detected by Calculation

ABSURD TEST RESULTS WERE TRACED TO STEAM LOSSES THROUGH A TRAP. BY GEORGE F. NORDENHOLT

SUCH a small and simple apparatus as a steam trap is very likely to cause a greater loss resulting from its failure to operate properly than one would expect. In fact, in testing the performance of a steam power plant, the steam traps are not usually considered. Yet, as in the case of the test described herewith, the failure of a steam trap to function properly will result in absurd data on the test and of course be the cause of a considerable operating loss.

The plant on which this test was run consisted of a boiler, compound reciprocating engine, vacuum pump and surface condenser, boiler feed-water heater of the open type, boiler feed pump and a 5-hp. high speed engine. The exhausts from the boiler feed pump, high speed engine and condenser pump, discharged into the feed-water heater. The drips from the steam lines and the jackets around the cylinders of the compound engine, were led to steam traps, which also discharged into the open feed-water heater. During the running of the test, the condensate from the main engine was weighed, so that with the exception of the steam and water received by the heater as stated above raw feed water was supplied to the boiler. This raw feed water came into the heater at a temperature of 50 deg. F. and the feed to the boiler was at a temperature of 210 to 211 deg. F.

After the end of the first hour of the test, it was found that the weight of condensate from the main engine was 4000 lb. per hr., in round numbers. Similarly the weight of water fed to the boiler was 8000 lb., while the coal fired was 1200 lb.

It was evident that something was wrong, either in the operation of the test or with the plant, as twice as much water was fed to the boilers as was consumed by the engine. An inspection of the scales used showed them to be in proper condition and weighing correctly. Further inspection of the data showed the boiler to be generating 6.66 lb. of steam per pound of coal fired and after computing the indicated horsepower of the engine, it was found to be consuming 19 lb. of steam per horsepower. These are both reasonable amounts.

In order to check the data still further, the following calculations were made. It was assumed that the 5-hp. high speed engine was consuming 40 lb. of steam per hp.-hr., on which basis it would have been exhausting 200 lb. of steam per hour into the feed-water heater. In order to be on the safe side, it was assumed that the two other engines, the vacuum and boiler feed pumps, were exhausting together, 600 lb. of steam per hour, making a total of 800 lb. per hr. It was also assumed that this exhaust steam had a quality of 0.80. On this basis, the exhaust steam at atmospheric pressure, contained $180 + 0.80 \times 970 = 976$ B.t.u. per pound, above 32 deg. F., or 776 B.t.u. above 212 deg. F., the assumption being made in the calculations that the feed water lost 1 to 2 deg. after leaving the heater. Therefore, for every pound of exhaust steam, there was 776 B.t.u. available for heating raw feed water at 50 deg. F. to a temperature of 212 deg. F., which requires 162 B.t.u. Thus, every pound of exhaust steam was capable of heating $776 \div 162 = 4.8$ lb. of raw feed from 50 to 212 deg. F., the mixture resulting in 5.8 lb. of hot feed. The 800 lb. of exhaust steam could therefore result in $5.8 \times 800 = 4640$ lb. of hot feed water, assuming a heater efficiency of 100 per cent. To make 8000 lb. of hot feed, would require the traps to discharge sufficient hot water to make $8000 - 4640 = 3360$ lb. of hot water per hour.

Assuming that the traps discharged water at the vaporizing temperature, the pounds of hot feed per pound of trap discharge, would be as follows: The pressure in the traps was 120 lb. per sq. in. gage, for which pressure the heat of the liquid is 312 B.t.u. This makes available 132 B.t.u. for heating the raw feed from 50 to 212 deg. F. This latter requires 162 B.t.u. per lb., therefore, 1 lb. of trap discharge could heat $132 \div 162 = 0.82$ lb. of raw feed, resulting in 1.82 lb. of hot feed. To furnish 3360 lb. of hot feed would therefore require $3360 \div 1.82 =$ 1846 lb. of trap discharge.

If all the assumptions made in connection with the above calculations were correct, then 1846 lb. of steam must have been condensed in the steam mains and jackets. Furthermore, the assumption that 800 lb. of steam per hour at a quality of 0.80 was exhausted by the auxiliaries into the feed-water heater, is undoubtedly higher than the actual, both as to weight and quality. This, together with the heat losses in the heater, requires that the discharge from the traps must have been considerably greater than the figure 1846 lb., as computed.

It would be absurd to accept the figure 1846, as the number of pounds of steam condensed in one hour, in the steam mains and the jackets. Yet the calculations show that considerably more than 1846 lb. per hr. was discharged by the traps. The only plausible explanation that remains is that one or more of the steam traps were not operating properly and were allowing the steam to pass through freely, thus circulating steam from the boiler through the traps and into the heater. This explanation appeared to be still more plausible when it was observed that great clouds of steam were issuing from the atmosphere pipe of the feed-water heater.

The distribution of the steam consumption according to the above calculations, was:

Main Engine	4000 lb. per hr.
Auxiliaries	800 lb. per hr.
Trap Discharge	1846 lb. per hr.
Unaccounted for	1354 lb. per hr.
Total (Water fed to boilers)	8000 lb. per hr.

The probable correct distribution may have been:

Main Engine	4000 lb per hr.
Auxiliaries	600 lb. per hr.
Trap discharge, leakages, etc.	3400 lb.per hr.
Total (Water fed to boiler)	8000 lb. per hr.

If the plant had been in proper operation, the steam consumption would have been about as follows:

Main Engine .....4000 lb. per hr.
Jackets, traps, auxiliaries,
etc. .....1200 lb.per hr.
Water fed to boilers.....5200 lb. per hr.

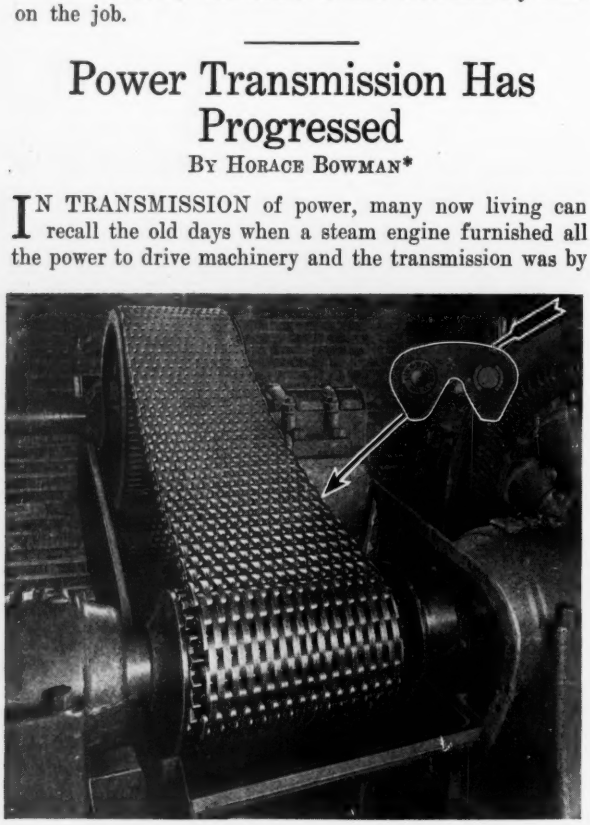
These last figures were obtained from previous tests. The feed-water temperature in these previous tests was only 118 deg. F. The loss due to the faulty operation of the traps was 8000 lb. minus 5200 lb., which equals 2800 lb. of steam per hr. In computing the heat loss, one must take into account that in the one case the feed-water temperature was 211 deg. F., while in the other case, 118 deg. F. It is evident, however, that a loss of about 30 per cent occurred in the one case due to the faulty operation of the traps.

These tests show forcefully that no matter how small and simple a piece of apparatus may be, it must receive its proper share of attention. The smallest pinion may throw out of operation a whole train of gears. Too often one is likely to judge importance by size and thus neglect the little fellows, who sooner or later rebel and lay down on the job.

Power Transmission Has Progressed

By Horace Bowman*

IN TRANSMISSION of power, many now living can recall the old days when a steam engine furnished all the power to drive machinery and the transmission was by



SILENT CHAIN MAKES INDIVIDUAL DRIVE POSITIVE

belts, pulleys and shafting, often with a loss of as much as 60 per cent of the power. With the introduction of electricity, there came a change to motors driving by belts, either individual machines or a section of shafting from which groups of machines were driven, thus saving the cost and friction of long lines of shafting and of long, heavy belts. Each method has its advocates and each its proper place.

Individual drive was so greatly improved by the introduction of the silent chain in 1902 by James Mapes Dodge, that to the writer, the economy of the individual drive is obvious. Some of its advantages are as follows: Individual drive may cost somewhat more for the motors, chains, switches and wiring than the group drive with its shafting, hangers, pulleys, belting and wiring but the maintenance and depreciation will be less for the former. With individual drive, machines can be placed to give the best light for the workmen and to use floor space to the best advantage; also production is increased because of the more complete and convenient control of each machine. Each machine can be run as required, regardless of the condition or requirements of other machines and in case of breakage of a machine, the motor fuse will usually blow, thus acting as a safety device, but shutting down only the one machine. Furthermore, with silent chain drive, cleanliness and perfect lubrication are possible with as great flexibility as belting and as positive drive as gears.

Invention of the detachable link chain by William Dana Ewart 50 yr. ago was the real start of chain transmission. From it has developed, not only the various types of conveyor and power transmission chains but the silent chain is an outgrowth of this work. It has an acknowledged place in industry and the writer believes that a wider field of application will be found as engineers study its advantages and possibilities.

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Uniflow vs. Corliss Engines

By W. F. Schaphorst

HERE IS an interesting table which I compiled from a chart comparing the mean effective pressures of uniflow engines of various initial pressures with those of Corliss engines of various initial pressures. It shows that the Corliss engine has the advantage so far as pressure is concerned where both types are condensing. But where both types are non-condensing the uniflow "passes" the Corliss and shows higher pressures at 40 per cent cutoff.

The engineer in the plant where both Corliss and uniflow engines are commonly used, will find these facts of interest and value because it is the mean effective pressure that really determines the "size" of engine to buy for any given purpose. Every engineer knows that the horsepower of a steam engine is directly proportional to the mean effective pressure, all other factors being equal such as length of stroke, diameter of cylinder, and speed.

The reason why there is a difference in pressure in these two types of engines lies in the fact that there is a difference in compression. Compression begins later in the Corliss than in the uniflow. The greater the compression, of course, the greater the back pressure, and since back pressures must always be deducted from active pressure the Corliss engine benefits in most cases. This is a point worth remembering.

Mean Effective Pressure

Type	Pressure Lb. per sq. in. Gage	Condensing or Non-condensing	Cut-off 10%	Cut-off 25%	Cut-off 40%
Uniflow	125	Non-condensing	36	68	91
Corliss	125	Non-condensing	38	69	89
Uniflow	125	Condensing	45	76	98
Corliss	125	Condensing	50	85	109
Uniflow	150	Non-condensing	42	81	106
Corliss	150	Non-condensing	53	83	104
Uniflow	150	Condensing	54	92	117
Corliss	150	Condensing	65	100	124

Low Condenser Pressure Aids Ice Plant Operation

REMOVAL OF SUPERHEAT FROM GAS AND GOOD CIRCULATION OF WATER AND AMMONIA GIVE LOWER CONDENSER PRESSURE. BY A. G. SOLOMON

NO MATTER where the refrigerating plant is located, the question of the proper condenser pressure is always a matter for discussion and argument. The capacity of the plant does not make any difference. An ice machine rated at one ton of refrigerating capacity per 24 hr. furnishes the same problem as one of the large plants in which the total capacity is from 1000 to 5000 T. Whether the entire refrigerating plant consists of one small "butcher box" machine or a great number of large compressors, the removal of the heat from the ammonia is the principal object.

Ammonia condensers are heat unloading stations. All the heat units taken up by the ammonia must be removed and the ammonia made ready to receive another load. Whether the ammonia will take up a real, full-capacity load or only part of a load will depend on the thoroughness of the heat unloading service performed at the ammonia condenser.

Such a condenser has three distinct duties to perform: First, the superheat must be taken from the discharged ammonia gas; second, the ammonia must be liquefied; third, the temperature of the liquid must be lowered to the lowest temperature it is possible to reach with the cooling water. If there are any ways of helping the condenser to perform its threefold duty more efficiently, the condenser will respond by giving greater service.

AMMONIA IS DESUPERHEATED BEFORE ENTERING CONDENSER

One of the first points at which help can be extended is along the discharge line between the ammonia compressor and the condenser, by installing some apparatus to remove some of the superheat from the gas during its travel to the condenser. Several types of discharge-gas water heaters now on the market have shown good results. Even if the heated water is not needed, the gain derived by cooling the gas will more than repay for the water used. Liquefying of the ammonia cannot begin in the condenser until the temperature of the ammonia gas corresponds to the temperature of saturated vapor at the condenser pressure carried. Therefore every heat unit taken from the ammonia gas before it reaches the condenser means just that much less work for the latter.

Water that has already been used over the ammonia condenser or in the water jackets of the compressors will be suitable to circulate for the removing of heat from the discharged gas. After leaving the heater, this water can be used in the dip tank for thawing the ice from the cans or it can be sent to the boiler feed-water heater.

By removing heat from the ammonia in the discharge line, the condenser pressure will be lowered 10 to 25 lb. This means a great saving in power or fuel. Circulate as much water as possible through the apparatus for the removal of the superheat. Now the ammonia will be in a state more nearly saturated than before and the liquefaction will take place quicker, which really means that the condenser will handle a greater amount of ammonia.

If the condenser is of the double-pipe, shell-and-tube or multi-tube type, circulate as much water as is available. The atmospheric type of condenser is somewhat limited as to the amount of water that can be circulated to good advantage. See that every part of the surface is flooded, but do not waste water by circulating more than enough to cover the coils completely. Allow the water to flow freely over the return bends at both ends of every coil. These return bends amount to many square feet of surface and advantage should be taken of this fact.

AMMONIA CIRCULATION SHOULD BE WATCHED

Bear in mind, too, that the ammonia condenser is not a storage space or a liquid receiver. As soon as the ammonia is liquefied and cooled to within 5 to 8 deg. of the cooling water temperature, it should pass from the condenser. The condenser can do no more work on this ammonia and the space is needed for the gas that is being sent from the compressor.

Watch the condenser and see that every coil is working as nearly the same as possible. Make a habit of feeling the return bends of each coil. A sluggish coil will have a lower temperature than those that are working properly. Often one coil will discharge its liquid so slowly that some of the pipes will be filled with cold liquid. This liquid is ready to pass on and take up heat, therefore it must not be allowed to stay in the condenser. Generally all the coils can be kept working evenly by regulating the flow of the cooling water. A slow working coil must have its water supply reduced.

If the ammonia condenser is large enough to handle the full load of heat in mid-summer, it must be true that all of the surface is not needed during cool weather when the load is light. Too much condenser is not as bad as too little, but it is troublesome and is often the cause of costly operation.

When all the stands of the condenser are not needed, as in cool weather, some of them will discharge the cooled liquid so slowly that the working charge of ammonia is so low that the compressor must operate with greater horsepower per ton of refrigeration. Thus the efficiency of the compressor is reduced by the handling of vapor at a low back pressure.

CONDENSER SURFACE MAY BE REDUCED IN COOL WEATHER

It often happens, also, that such an over-size condenser will discharge liquid in slugs. This irregular flow of ammonia will demand frequent changing of the expansion valves. All refrigerating engineers know that when the position of the expansion valves is changed often, the results are not good. For these reasons, in cool weather or when the load is light, the amount of condenser surface should be reduced by shutting off as many stands as are not needed.

By taking care that every part of the condensing surface is liberally supplied with water and that the surfaces are free from scale, good results can be obtained. The liquid should leave the condenser at a temperature within 8 deg. of the temperature of the cooling water.

Non-condensible gases will cause high condensing pressure and low temperatures at the liquid outlet. This does not mean that the liquid temperature is lower than it should be, according to the temperature of the water. It does mean that the pressure is higher than that at which the vapor should liquefy. By keeping the ammonia pure and free from non-condensible gases, the condenser pressure should be within 10 lb. of the pressure that corresponds to the evaporating ammonia temperature. Ammonia pressure and temperature tables should be studied and the operating conditions of the plant closely checked by means of both pressure gages and thermometers.

Piping for High Pressures and Temperatures*

Small Diameters, Corrugated Expansion Bends, Few Valves and Welded Joints Recommended. By J. Arthur Aiton

PIPING to be considered will be for carrying steam at a maximum pressure of 400 lb. and temperature of 750 deg. F. Such conditions produce no new difficulties but they do accentuate all the old ones.

While it is not to be expected that a station shall be designed around the piping system, it is also essential that no undue difficulties be introduced by the placing of apparatus to be connected as this often forces the placing of piping in a run that the engineer knows is not the best way. Simplicity and directness should be first considerations, with provision for expansion due to change in temperature but with care to avoid other causes of movement and distortion. Reliability is now such that duplicate systems are not needed. Such systems are not only costly but, by complication, increase the risk of breakdown and the radiation losses.

Diameter of piping for high pressure steam should be kept small by using high velocity flow, allowing as high as 10 lb. pressure drop. This sounds high but is not great as compared with the initial pressure and loss in pressure is compensated by reduction of radiation losses and capital investment. Besides, the full drop is incurred only at maximum load and falls off rapidly as the load decreases.

Expansion Provisions

With high superheat, expansion is a serious problem and is the ultimate cause of most trouble in pipe lines. Even troubles at joints may often be traced to undue stress on the flanges caused by expansion. Expansion due to temperature can be met by expansion bends, which are best introduced by using long turns in the run of the pipe but, where this is impossible, can be made up in lyre form. It is well to allow the piping to be drawn up when cold to the amount of 1/3 the expansion expected when hot.

To overcome the difficulty of large space for bends needed with the larger sizes of pipe, bends made of corrugated pipe are now being used. These are more flexible than plain pipe and, for a given size of bend, will allow five times the expansion of the plain bend or can be made much smaller than the plain bend to care for a given expansion. Corrugated pipe can be bent to a smaller radius than plain pipe, even small enough to be used in place of a cast elbow, but, when used to this size, there is little expansion movement. It is easily bent, preferably hot, but need not be filled with sand and bends require less thrust than those of plain pipe to spring them. Friction of steam in passing corrugated bends is about double that for plain bends but, as the number of bends can be reduced to one-fifth that needed for plain pipe, the loss is compensated.

Water pockets must be avoided at all costs and where settlement cannot be avoided, as on top of valves, bypass drains must be provided. The best way is to use as few valves as possible and keep these at the high points of the lines which they control.

Injudicious anchoring causes stresses by trying to force the pipe where it would not naturally go. The ideal plan would be a system without anchoring, simply guiding the pipe in the direction in which expansion should take place. This can seldom be attained but should be aimed at in all cases.

Joints Need Special Care

As joints are the weakest part of the system, they should be kept at a minimum by making the lengths as long as possible. It is possible to get pipe up to 30 ft. long now, if transportation facilities permit. Welding up lengths on the job may be permissible but, if high pressures are to be used, the greatest care should be taken in making and testing the welds. How to attach the flanges and how to make the joint are the two main questions to consider. For the flanges, riveting and welding are the methods used, except in small pipe where they may be screwed on. A satisfactory job can be made by riveting but, if a rivet does leak under high pressure, it is almost impossible to stop the leak. The row of rivet heads, inside the pipe and close together, does also cut down the pipe area appreciably and cause a drop in pressure.

Welding on by the carbon rod process is, in the opinion of the writer, the only entirely satisfactory method. A continuous weld should be made right through from front to back of the flange and, in addition, a good fillet worked up at the back of the flange. Attempting to calk a leaky weld is poor policy.

Flanges must be heavy to avoid springing and the joint should be made on a ground surface inside the bolt circle, though the ground face is not essential. Care should be taken, however, that strains are not put on the joints, particularly bending strains. If this is done, a good faced joint with a thin wash of pipe cement and an ordinary corrugated metal gasket will serve admirably. Water must be kept out, as collection of water at a joint, alternately heated and cooled, will soon destroy any cement; also, an electrolytic action may be set up which will soon destroy the joint. Bolts made of steel of 30 to 35 T. per sq. in. tensile strength have given good satisfaction but high-tensile steel has shown a liability to brittleness after being subjected to changes in temperature.

Branches should be welded on, the oxy-acetylene process having proved best for this work. The branch should be welded onto rather than into the main, so that the joint will be inside the branch where it can be reached with blow pipe and hammer. Cast steel fittings must not be used for this class of work and riveted-on nozzles are often not satisfactory.

Separation of water from the steam requires only a simple reversal of flow in the separator. There should be no joint in the water space of the separator, hence, welding up is the most satisfactory method of manufacture. It is found that special means must be used to give good results at high pressures and the body seams are made by the water gas process, ends and flanges put on by the carbon arc process and branches by using oxy-acetylene, carrying the branches through the wall and welding them both inside and out.

To meet modern conditions, care and experience are necessary, especially in the design of the pipe system, which is the only important part of a station that the manufacturer of apparatus is not expected to design. Experience of the pipe manufacturer and contractor should be taken advantage of by the engineer and they should be consulted while the design is being made. Then responsibility should be put on them and as definite guarantees demanded as for any other part of the plant.

*From a paper before the Institution of Engineers and Shipbuilders in Scotland. Reported in Engineering of London.

Tribulations of the Pocketbook Engineers

THE TRUE STORY OF TWO COLLEGE BOYS WHO HUNG OUT THEIR SHINGLE IN CHICAGO AND WITH THE FLAME OF AMBITION BURNING AND ENCOURAGING RELATIVES (WHOSE MONEY THEY HAD BORROWED) TO GIVE THEM ADVICE, STARTED ON THE STONY PATH TO KNOWLEDGE. BY B. GOODE

"EVERY TIME we went into the lobby," began Albert Hall, "we would rivet our attention on the directory just for the sheer pleasure of seeing our name listed there among "those present." We were never done admiring the Greek architecture of the towering office building, the white marble, the grillework and all that kind of thing. We were flattered if the elevator boy called us by name, or knew where we had to stop without calling the floor. We were very young. Our shingle was just hung out, and Wight & Hall, power plant specialists, looked good in our eyes.

"We buckled right down to work, however, made up lists of prospects, used our telephone freely both for business, but more for personal calls, and solicited by various methods. We looked out for open bids, and lo and behold! when one day the consul of a republic in South America answered on his official stationery that he was in the market for a certain kind of equipment for his government, our heads were in the clouds. There was no end to the castles in the air we built before we finally decided that the thing to do was to go see the consul."

Mr. Hall grinned reminiscently.

"We found him a fat, affable little gentleman quite open to any suggestions and he explained in a kind of nonchalant manner that he had a little order of some quarter of a million dollars—as he said, "only ze small contract." I daren't look at Wight. "Ze small contract!" We staggered out of the office after a further hour of conversation and in our excitement walked round our block three times before we finally entered. Excited! We were so excited that we talked for hours and hours without getting anywhere."

"Finally it turned out that Wight had heard of a man who made a specialty of the kind of oil engines that were required for the Republic. We decided to look him up. And we did—"

"And we did," repeated Mr. Hall thoughtfully. "Yes, we called on Mr. Taylor in his beautifully appointed offices, were impressed by the number of employes, the mahogany furniture and the long drafting tables where blue prints were being studied by men wearing eye shields.

"Gosh," I whispered to Wight, "this looks like a pretty good firm to me, must have something behind it to back up all this pay roll?"

"In due course we met the imposing Mr. Taylor. He was a keen looking, well-bred man some 40 years old who had just the right air of convincing sincerity. We instinctively trusted him. Cautiously at first we told him of our prospect, the material needed, and all the time he led us on by gentle questions until finally we came out into the open."

"Mr. Taylor then proposed an affiliation. It sounded good and it was good. We were to represent the Taylor Industrial Works exclusively and the financial arrangement we made was fine. Both of us were to get a good slice out of the Consul's little contract, and we left feeling that we would soon be installing our best girls in the best houses in Evanston.

"Yes, sir, all was sitting pretty, and pepped up by an enthusiastic display of mutual enthusiasm our respective families were treated to mysterious allusions to great wealth, 'You'll be proud of us some day' and 'Watch Wight & Hall' for many weeks.

"Fired by this initial success, for the Consul fell in, for some reason known only to his good nature, with our every plan, we went ahead with other solicitations. We had by this time got an ample supply of the Taylor literature and Wight went out on the road calling on small municipalities while I kept both swivel chairs warmed and made dates with different girls for several weeks ahead. Also I may add, made liberal use of our engraved stationery in bright letters to the old 'frat' boys.

"In a way, it was a cinch. According to the Taylor catalog, which called itself 'An Idea Materialized' and was illustrated on the best enameled stock with profuse use of art work, the 'Taylor Principle' Oil Engine met all the tests for reliability, simplicity, and economy. That last was the trump card of poor old Wight on the road. When he explained to the authorities that whereas they were now operating at an expense of 25 cents a kilowatt-hour, and the Taylor engine would operate with less man power, more reliability, and all for half-a-cent a kilowatt-hour delivered power at the switchboard, there was nothing else for them to do but to tell him to go to it and get all the necessary data and specifications ready for submission to their respective Boards.

"Say, when Wight's reports and letters came in, did I burn the midnight oil getting the details on paper? I'll say I did. Summary of Costs, Estimated Costs on 1000 Boiler Horsepower Hours, Costs of Repairs and Replacements, Costs of Unloading, Costs of Consumption and every known kind of cost was figured out to a degree. Wight & Hall were going to start this thing on the right kind of basis."

Mr. Hall had forgotten to smile. There was a trace of sadness in his face as he continued with the story of their early beginnings.

"By this time the consul was receiving wires from his government for the appearance of the engines promised. With Wight on the road, I started to press Taylor." "Oh, we'll have them," he said, "what are you worrying about? They will be here in 30 days."

"I called Wight in. The look of things began to worry me.

"Wight got in at eleven o'clock the following day, and we went straight up to the office, walking the 19 floors with no conscious effort. He was full of vim and had his portfolio stuffed with prospects he had picked up everywhere. I'll never forget the way he seized my hand.

"'Al,' he said, 'we're goin' good. As power plant specialists we have 'em all beat.'

"Then I started to show him the correspondence from our good-natured friend the consul, who was getting somewhat impatient in his polite way. Four months had rolled on and no sign of the engines. His people were asking 'How come?'

"There were a few days after that when Wight and I didn't eat and didn't sleep, and grief and rage consumed

us. When the whole world was black, and all our puny curses were uttered with a half sob.

"Taylor had 'An Idea' sure enough. But it was not an 'Idea Materialized.' We went down to the big manufacturing works at Joliet where we found a little engine sitting forlornly in a far corner, with an accumulated heap of dirt surrounding it. The foreman in charge said that Taylor had promised them the contract for making the engines when he had perfected his wonderful atomizer."

"Our investigation took 5 min. On the train going back we had a vivid recollection of the Conference between the President of the Anhalt Products Co., his two chief engineers, we two, and Taylor held in Taylor's swell offices. They had signed the dotted line for delivery of a four hundred thousand order."

"There was nothing we could do but get out. Taylor had sold stock to widows and the usual sucker list. Without conscience, suave, and merciless, he had used our efforts to promulgate his schemes of stock selling.

"We left the thick green carpets, the large book cases, the sunny windows, the quartered oak furniture and in an obscure part of South Dearborn Street, installed ourselves in an unswept, unwashed and tiny back office, no longer 'power plant specialists,' but engineers merely, whose capital was down to zero, but who were determined to make good from the bottom up instead of from the top down.

"By dint of scouring around we secured an order on open bid for the installation of oil burning equipment in a laundry way out on the west side. There was barely a hundred dollar profit in the whole thing for us, but we figured it would be a start and could be used for a reference.

"The Laborer's Union were having difficulties at that time, and we couldn't get a laborer. Finally we did get a Landis Award man, and then we started. Neither of us had ever done the rough practical work of plumbing. We knew we had to have tools; a good hearted uncle of Wight's allowed us to rifle his garage and we finally packed a vise, pipe cutter and threader, a couple of wrenches and a file or two. The whole outfit went into a small brown case.

"Somehow we were ashamed to enter the laundry boldly and start the work. With one accord we got off a block before the laundry and sneaked up a side alley and mostly under the directions of our laborer, commenced work.

"It took us all morning to set up our vise. And when Crew, the owner of the laundry came into the basement to have a look at us, he put his hand to his mouth, turned his back and guffawed himself out. We knew he was the Secretary of the 'Plumbers' Union' in Chicago and this was one of the reasons why we had not wished to proclaim our presence or broadcast our ignorance.

"He came back a few minutes later and said in a kindly way, 'Boys, if you need any tools I have my old kit somewhere around. In the meantime perhaps you would do better if you were to set the vise up straight.'

"After all our work we had gotten it upside down. No wonder he laughed.

"Our laborer was a good practical man, and we two young College graduates were humble and submissive in the presence of this our master. We worked like galley slaves and finally the 1000-gal. tank was ready to be slipped into its excavation. We had no pulleys, no nothing. We did 'borrow' a few planks from a neighboring lumber yard when the nightwatchman had turned his back, and then we were ready.

"If our pride had not been roused we couldn't have gone on with the work. Getting those nipples right! Inch by inch we worked the tank by means of the planks till finally we had lowered it. If Wight and I hadn't played football we could never have stood the strain.

"But Crew was a good sport. He acted as a reference on every other little job we landed and by and by we got a word-by-mouth reputation as close figurers, hard sluggers and cheerful curiosities. We began to forget about the roll top desks and thick carpets of our start and were content to accept anything that came our way. We were no specialists, and the fact that we had only one good chair in our office ceased to worry us.

"For a couple of years we stuck it out, years of hard work, worry but rich in experience. Finally we won out.

"The rest is the usual story," smiled Mr. Hall, refusing to add any more.

* * *

For a number of years Wight & Hall were known as the "Pocketbook Engineers" and many of the readers of this publication will so recall them. With indomitable pluck and their tools in a small case they profited by every experience, no matter how bitter. The partnership is now dissolved, for Mr. Wight has acquired engineering interests in Florida and Mr. Hall is well known in Chicago. But they will always be known in their respective spheres as the "Pocketbook Engineers."

Weld Repair on Pump Causes Explosion

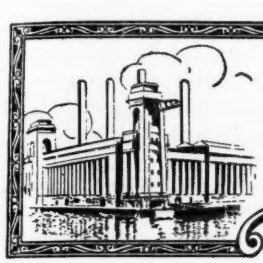
By R. L. Hemingway

TWO YOUNG men recently set up in business as jobbing welders, and were about at that stage when they had established a connection which promised to develop into a prosperous partnership. One day, a stator or casing of a small centrifugal pump was sent to them for repairs, which involved the preheating of the whole casting. No sooner was the welding torch applied, following the preheating, than there was a terrific explosion which blew out one end wall of the casting, so severely injuring the right arm of one of the partners that amputation above the elbow was found necessary.

Our readers may ask, "Why should this casting explode?" The answer lies in the fact that it was part of a water pump which had gradually allowed water to seep through its pores or through the central shaft bushing into the cored part of the casting. Some corrosion or incrustation followed, thus effectually sealing the interstices and preventing the water from escaping either as water or steam when heat was applied.

In this case, the preheating undoubtedly generated a steam pressure approximately to the bursting pressure of the cylinder and the application of the welding torch probably created a local weakness, which, under the internal stress already existing, caused the violent explosion that cost a young and vigorous man his good right arm.

What preventive steps could have been taken to avoid this regrettable mishap? A very simple one, so simple indeed that one wonders why it was overlooked. The drilling of a ½-in. diameter hole into the annular space would have entirely prevented all possible chance of any accumulation of pressure.—California Safety News.



LETTERS DIRECT FROM THE PLANT

Superheated Air Is Put Into H. R. T. Boiler Below Water Line

AT A RECENT engineers' meeting, a device developed and patented by an engineer in this district and illustrated in the accompanying sketch was called to my attention. A super-heater composed of a home-made bank or coil of pipe was installed in the combustion chamber of an H. R. T. boiler. Air from a compressor was forced through this superheater; the pipe leading from it was carried out through the top of the combustion chamber as shown, and down through the top of the shell. Here it was connected with a pipe running horizontally above the tubes below the water line, capped on the end. The pipe has numerous small holes drilled in it, and the end is capped; the air is discharged under the water towards the top of the shell.

Before this device was installed, according to reports, two boilers were required to do the work, now being done by one boiler with the air superheater. The boiler handles the load easily and burns less fuel than before. The boiler is installed in a hotel, the steam being used only for heating and cooking. It is insured by a liability company, whose inspectors are watching it closely.

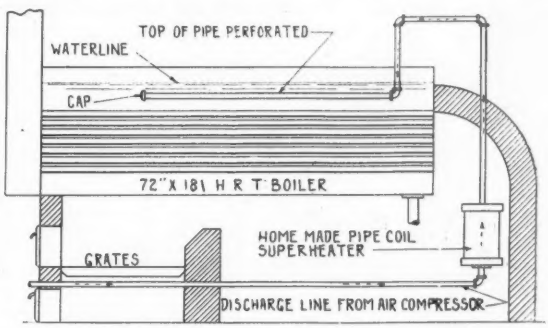
Several questions in regard to this device have occurred to me. How well do steam and air mix? How would the mixture work if used for heating only in a one-pipe gravity-return heating system? One of the hardest propositions I ever ran across was to get out and keep out the air from such a system. How would it work used for heating only with a vacuum return system? In proportion, a small amount of air seems to have a bad effect on the operation of the pump used to maintain the vacuum and handle the return condensate of a vacuum system.

Recently a writer described the trouble caused by air trapped in a boiler, which destroyed the vacuum in the condenser when the boiler was cut in on the line with the engines running. How would it work, when running engines condensing, to have a continuous supply of air injected into the boiler? Would there not be danger of the air, after being superheated, absorbing moisture from the water and steam in the boiler and giving us a greater saturation of the steam? All that I have ever been able to gather on the subject seems to emphasize the idea of keeping air and moisture out of steam.

To what degree the superheating of the air in this case is carried, I do not know, nor have I been able to find anyone who seems to have any idea; but I should imagine that it is higher than the heat of the steam. As I understand it, the better the circulation in a steam generator, the better it steams. Perhaps the liberation of air under the surface of the water has increased the circulation in this boiler. Why would it not be just as economical to use a centrifugal pump and circulate the water through the same kind of a device? It costs money to compress air and there is a doubt in my mind whether the benefits received justify the cost.

Minneapolis, Minn. FRED S. RUTLEDGE.

In reviewing the history and development of steam engineering, we find that the use of air and steam combined as a medium for developing power is not of recent origin. The value of air in preventing rapid condensation of steam was known by Savery and other scientists before 1800 and was utilized by them, in the operation of water pumps, by interposing a layer of air instead of a piston



SKETCH SHOWING PATH OF AIR FROM COMPRESSOR, THROUGH SUPERHEATER AND INTO BOILER

between the steam and the water. In 1873, Osborne Reynolds of Cambridge, England, made an investigation to ascertain the effects of a small quantity of air on the power of a cold surface to condense steam.

Various attempts have been made to put air—steam mixtures to practical use. In 1870, a plan of providing a mixture by forcing high temperature air into the boiler from coils of pipe in the hot flue, much like the device described above, was given a great deal of publicity. This plan, which finally became known as Warsop's System, was adopted by the Lancashire and Yorkshire Railway, and also installed successfully in several vessels. It was reported that 10 or 12 per cent of air in the mixture gave best results.

Andrew Jamieson, at a meeting of the Institution of Engineers and Shipbuilders, held in Scotland on April 30, 1895, read a paper entitled "A New Departure in Steam Engine Economy, with a Detailed Description of Tests of Field's Steam and Hot Air Engine."

Many other attempts were made along this line but a detailed description of them cannot be given in this article. Enough has been said, however, to show that the idea is not new.

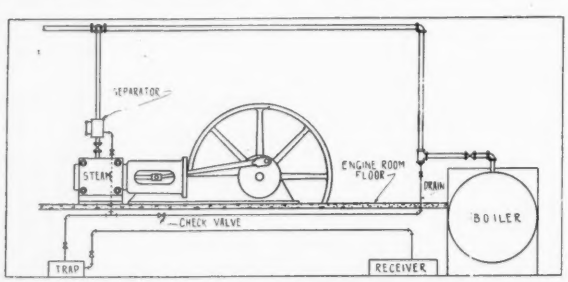
Investigations of air-steam mixtures used in a steam engine, made in 1923 by C. R. Richards and J. N. Vedder, the results of which have been presented in Bulletin 130 issued by the University of Illinois Experiment Station, show that the use of air mixed with the steam tends to

reduce cylinder condensation. No figures were available as to the overall economy of the power plant.

It is known, of course, that air in boiler feed water causes pitting; deaeration of feed water is practiced extensively in modern power plants. It is probable, as stated above, that the introduction of air into the boiler would cause complications in a heating system, as well as in a condensing engine or turbine. Since the steam from the boiler described above is used only for heating and cooking, it may be that the over-all economy of the plant has been increased. The effect of the air on the boiler itself could be determined by careful inspection and possibly by observing the corrosion of zinc plates placed in the drum.—Editor.

Condensation Removed From Steam Line

W. H. WAKEMAN'S article in the February 15 issue, under the heading of "Condensation in Steam Lines" prompts me to give a brief description of piping between the boiler and the engine in a laundry plant where I am employed as engineer. The plant is in operation during the day only. In closing down at night, we always close



DRIPS ARE TRAPPED TO A RECEIVER

both engine throttle and main boiler valves. A glance at the accompanying sketch will show why we are never bothered with condensation in the boiler main or the engine supply pipe. It is taken care of by a steam trap which water supply to the boiler.

This arrangement takes care of the situation admirably. In the morning on starting up, the only condensation present is the small amount that collects between the separator and throttle valve which is easily gotten rid of if ordinary care is taken.

Morris Plains, N. J. GEO. M. HILL, JR.

Common Sense Solves Many Problems

OCCASIONALLY trouble arises in a power plant which, while of a simple nature and easily remedied if proper thought is given to the problem, often becomes quite serious simply because some one does not use his head.

I recall an incident which occurred at night in a plant where a watchman was taking care of a couple of return tubular boilers. He allowed the steam pressure to go down too low for the injector to start, and as the boilers needed water, he started a feed pump and opened a valve to supply the pump with water from the city mains.

When the boilers were filled to their proper level, he stopped the pump but neglected to close the valve on the city water pipe. The boiler pressure evidently was reduced below the pressure in the water pipe, as the water continued to flow into the boilers. After stopping the pump, the watchman left on his hourly trip about the plant. Upon his return to the boiler room, he found water spouting from the high-water alarm whistles on the water columns. He became very much frightened and began yelling, and the noise aroused people living near by. A neighbor came out in his pajamas and bare feet and ran into the hot water on the floor of the boiler room, starting a still greater commotion, all because of a little careless or thoughtless action.

Another time an upright, double-acting reversible engine operating a large freight elevator was started on its first trip of the day. After a few revolutions the engine slowed down and stopped. In a short time it was again started with exactly the same results. This was repeated a number of times but the trouble could not be located. Finally the chief engineer and master mechanic were sent for and the engine was taken apart but the trouble could not be located. After several hours of frantic work, the steam was ordered shut off at the boilers and there it was found that the stop valve at the boilers was very nearly closed. It was open just enough to allow steam to escape from the boilers and fill the steam pipe with boiler pressure in a few moments, but the slight opening in the valve would maintain the pressure only long enough to start the engine and turn it over a few revolutions.

On another occasion, the engineer of a plant was obliged to leave for the day. An assistant was left in charge and the plant operated without incident until noon. The main engine could not be started after dinner, however, and as it had been shut down for only a half hour, it appeared to be quite a puzzling proposition. Several theories were advanced and all of them tried but they would not start the engine. Finally they gave it up and decided to wait for the return of the engineer. As soon as he appeared he placed the engine in starting position and then turned the throttle valve to an open position but the engine would not start. Telling the assistant to shut the steam off at the boilers, he took the bonnet off the throttle valve and found that the nut holding the valve disc on the valve stem had worked off, and as the pressure from the boiler was on top of the disc, it held the disc to its seat and no steam could enter the engine cylinder. The engineer made this discovery as soon as he tried to open the throttle valve by feeling that there was nothing attached to the valve stem. It was simply a case of using his head for something else besides a hat rack.

Superior, Wis. E. EMMERT.

When the Hydrostatic Lubricator Needs a Friend

YOU HAVE heard the expression, "When a feller needs a friend." After reading R. G. Summers's letter in the March 15 issue, I feel that this is the time our old staunch friend the hydrostatic gravity-feed lubricator that served us faithfully for many years and is still doing its bit in many plants, really needs someone to enumerate some of the good points Mr. Summers has apparently overlooked.

After mentioning some of the faults of our faithful servant, Mr. Summers makes the following statement: "Now with the force-feed lubricator, we have none of these ills." Let us take up in rotation the charges which he mentions.

(1) Forgetting to turn lubricator on. There is no excuse or forgiveness for the engineer who forgets. This

is the one great thing a real engineer must not do. The fact that a man may forget to test the safety valve is no reason for condemning the valve, if it should become set or otherwise inoperative.

(2) Forgetting to turn condensation on. The condenser pipe can be equipped with a check valve in many cases. There is no necessity for turning off the condensation except to make repairs, clean, or fill. A lubricator, including the joints and glass, will not leak at any time, except because of neglect, carelessness, or ignorance.

(3) Forgetting to regulate the feed. The automatic force-feed lubricators I have seen in operation do have to be regulated by adjusting the regulation screw very often indeed.

(4) Feed may be plugged. The feed on some types of force feed lubricators can and does get plugged, especially at the spring-loaded check valve and if the plug is not forced out, the pump is liable to get broken. Furthermore, some force-feed lubricators contain two pumps. One may stop working for various reasons and, although the machine is apparently feeding oil, it really is not doing so and the engineer may not notice this until the man who refills the lubricators reports the trouble.

(5) Blowing out glasses. I grant it is impossible to blow out a glass where there is no pressure, but it can be broken.

Leaving carelessness and forgetfulness out of the question, I will grant that the automatic force-feed lubricator is nearer fool proof than the hydrostatic gravity-feed type, but it has its faults, lots of them.

Toronto, Can. JOHN THORN.

Pulsations in Powdered Coal Fired Furnaces

IN AN ARTICLE appearing in the issue of March 1, doubt was expressed as to the cause of pulsations in boiler furnaces fired with pulverized coal. It seems clear that such pulsations might be caused by lack of sufficient air supply at the proper time and place to accomplish instant ignition of the volatile matter that is being rapidly distilled from the fuel.

If, in a grate fired furnace fresh coal is introduced and heated until the gases are being rapidly driven off, and then the draft and air supply decreased, a periodic ignition and extinguishing of the gaseous combustion which takes on the character of pulsations will result. It is evident that in this case the pulsations are caused primarily by the lack of sufficient air and the same might apply to the pulverized coal fired boiler. Here the method of admitting air may be more at fault than lack of sufficient quantity. This condition may be difficult to correct at the time for there is little control of the travel of the air and the gases in the furnace.

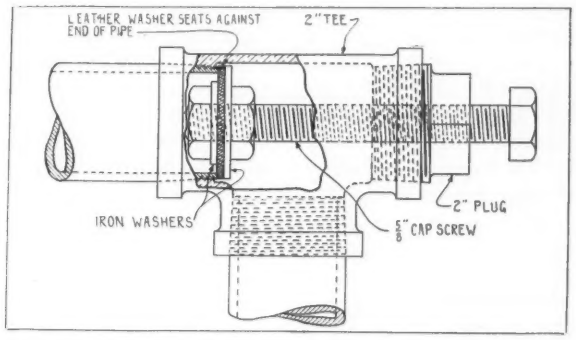
If for any reason a large quantity of gas fails of ignition at the proper time and then suddenly becomes ignited, it uses air at a more rapid rate than it is being admitted to the furnace, consequently sufficient air is not supplied for the ignition of the remaining gases that are being rapidly distilled from the fuel. The flame therefore dies out for a moment to reappear again with explosive force as soon as the air supply has become replenished. This periodic ignition and extinguishing of the flame will continue until mixing of the proper amount of air with the gases at the proper time has again taken place.

Combustion process with pulverized fuel differs from that with other methods of firing in that the particles of carbon are burned while traveling in a medium composed of a more or less complete mixture of air, burning gas, and inert gaseous products of combustion. Shortening of the flame so that combustion is completed within a reasonable distance from the tip of the burner would seem to be necessary in order to approach the control of conditions within the furnace.

Schenectady, N. Y. S. MARTIN.

Temporary Valve Is Made of Pipe Fitting

DURING ALTERATIONS to a service line, it was at times necessary to stop the flow of water and, since the pipe line could not be disturbed at a tee, we installed a home-made valve, which took the place of an angle valve.



SKETCH SHOWING METHOD OF HOLDING LEATHER VALVE DISC AND VALVE STEM

The plug of the 2 in. tee was taken out, drilled and tapped 5/8 in., as shown in the sketch. The valve stem is a long 5/8 in. cap screw and the valve disc is made of a leather washer with an iron washer and nut on each side. After the alterations were made, we took out our home-made valve and plugged the tapped hole in the 2 in. plug with a short 5/8 in. cap screw.

Death Valley, Calif. CHAS. LABBE.

Hot Water Heating Preferred in This Plant

REPLYING to your question as to why we would prefer the forced-circulation hot-water system over steam heating for our plant, as stated in my letter in the Feb. 15 issue, the following information about conditions in our plant may be of interest. I know that a discussion of the merits and defects of the two systems of heating factory buildings by any of the readers would be interesting and instructive to me, and probably to many others. I hope to see further comments from some of them.

We feel that it is not necessary to repeat the stock arguments in favor of either hot water or steam heating. Our heating system is a gravity return dry system; that is, there is both steam and water in the return lines except in a few instances where, in later years, we have had to put in a few sections working on the wet return principle. Originally the returns were carried in boxes of 2 in. shank,

the boxes packed with mineral wool. This proved unsatisfactory and expensive to maintain, so, as new buildings were put up, pipe tunnels were installed and as opportunity offered, the old buildings were tunnelled where most essential. As this system was put in about twenty-five years ago, since which time many improvements have been made, we feel there is no excuse for its not being the best in its line.

With a forced-circulation hot-water system, we feel that we would be able to run the returns where most convenient, overhead usually, at a lower cost for installation and maintenance. We believe also that there would be much less heat loss between the radiators and receiving tank, that the handling of the heating medium would be at one point, and because of this we would get better results, both as to care and economy. With hot water, we believe it would be easier, as well as more economical, to regulate the temperature of the circulating water to suit the weather conditions; also, with forced circulation, there is no doubt about the returns coming back. With the hot water system we could run our return pipes along the walls and drop into the floor at doors and passages if necessary.

I hear my friends who handle vacuum steam systems talking of having to introduce cold water into the pump suction, and even with a gravity system one sometimes has a little trouble. One advantage of a gravity steam system that has been properly laid out is that most of the air can be taken care of at the receiver.

When the factory power plant is running, the need for economy is not so great. It is the down time that cuts into the coal pile.

ANDERSON, IND. J. O. BENEFIEL.

Inefficient Handling of Workmen Costs Money

DURING A recent visit with a friend in his plant, as he had his work to perform I was left to my own devices when he was called out. So I went into the boiler room, as my interest in that end of plant greatly exceeds any I hold for any other department. I noticed the foreman's method of working his men, as I am more or less of a crank on that subject. That foreman was a complete failure; to prove it, the following is an incident I actually witnessed. A mechanic he called Tom was given a job to work on some safety valves. As it required some special tools, Tom went to the tool room and brought them up. Then, just as he got ready to start, he was called off that job by the foreman. As he stood responsible for the company tools, he went back to the tool room with them. Another man was told to take the job and Tom was sent to a stoker job. He took his tools and got the job started, when the foreman came and wanted him to go on a pipe flange, which required different tools. Tom had to make another trip to the tool box. The same thing was happening with all the crew, except three, who were pounding their hammers on the work bench and discussing the relative values of two of the lower priced automobiles. By actual count, through lack of system this foreman, with a crew of 12 repairmen, lost 60 man-hours of work, and the wages there for boiler room repairmen were $0.75 per hr. By not using judgment he was actually costing his firm $45 a day, or $13,500 a year.

But the worst feature of all was the effect on discipline. When any piece of equipment went into service there was no one man who could be held for the mistake and they all knew that, so it encouraged slovenly, careless work.

Some of you will say that this is an extreme case. That is admitted, but if we stop and analyze our own work, we shall see that we all do it to some extent. It doesn't take a Taylor expert to systematize. It takes the use of common sense and nearly everyone claims some of that commodity.

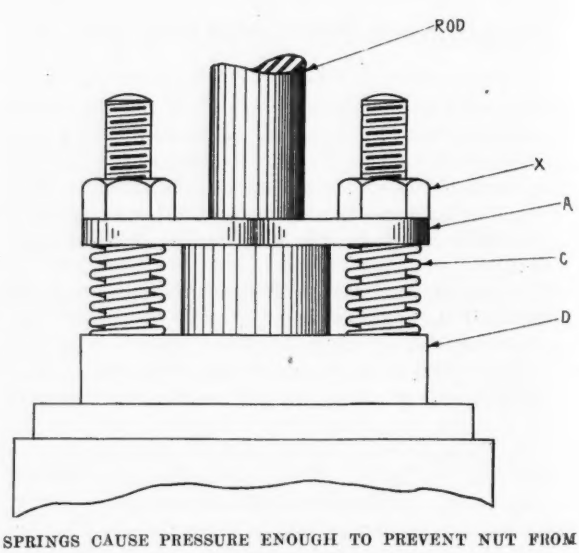
When a job is to be done, make one of your men responsible, preferably a man who likes that work. Let him finish it and, since he knows the responsibility is his, he will do a real job; when he says it's all right, you can believe it. Have a definite system of placing your men. Study them. Study the jobs. And you will be surprised how much better your plant will be maintained.

After all, one great necessity in the power plant is just plain, every-day "horse sense." Most operating men are never consulted when the management builds a new plant. They have to operate and maintain what they get. So just use your head and try to prevent such incidents as I just mentioned. They are too prevalent in plants that I have seen.

New Kensington, Pa. JAMES H. COX.

Springs May Replace Lock-Nuts

ON CERTAIN parts of engines and other machinery where there is vibration, it is sometimes possible to use springs instead of lock-nuts to keep various parts from

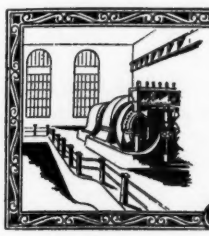


SPRINGS CAUSE PRESSURE ENOUGH TO PREVENT NUT FROM SHAKING LOOSE

shaking loose. One use of such springs on a stuffing-box is shown in the accompanying sketch. Instead of lock-nuts to keep nuts X from loosening, spiral springs placed over the studs, as shown at C in the sketch, will produce just enough bearing pressure between the nuts and the top of the stuffing box gland to keep them tight.

These springs should be long enough so that they will start to compress and exert a little pressure on A when the nuts are first started on the bolt threads.

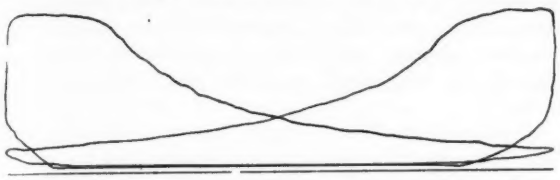
Toronto, Can. JAMES E. NOBLE.



QUESTIONS AND ANSWERS

Corliss Engine Pounds After Being Overhauled

ENCLOSED is an indicator diagram from our 22 by 36-in. Corliss engine, running at 120 r.p.m., which has just been overhauled by our engineers. Shortly after this engine



INDICATOR DIAGRAM TAKEN AFTER ENGINE WAS OVERHAULED

was put back into service, a pound developed, which seems to be in the crankpin. All wedges and bolts seem to be tight, and we are wondering if there is any fault in the valve settings that would cause such a pound.

C. E. B.

Why Does One Boiler Take All the Returns?

IT SEEMS to me that the trouble complained of by R. B. E. in the March 15 issue, is due to unbalanced pressure in the system of piping, due in turn to the design of the layout.

As it is at present, according to the sketch, there is one 2½-in. return pipe and another 2½-in. return pipe, both feeding into what may be termed a 2½-in. header from which two 2½-in. pipes carry the returns to the boilers through various fittings.

Taking the nominal diameters of the pipes (which are really somewhat smaller than the actual diameters), it is found that the cross-sectional area of a 2½-in. pipe is about 4.9 sq. in., and that of a 1½-in. pipe is about 1.8 sq. in. So the combined area of the two return pipes is about 6.7 sq. in.

Connecting piping to the two boilers from the two return pipes is made up of 2½-in. pipes and fittings. So the combined cross-sectional area of these two connections is $2 \times 4.9 = 9.8$ sq. in. or an area greater by 3.1 sq. in. than that of the two return supply pipes ($9.8 - 6.7 = 3.1$).

It looks as though the supply returns cannot furnish enough water to keep both of the 2½-in. boiler connection pipes full of water all the time and an irregular action results. This may be increased by a fluctuating rate of evaporation and slight difference of pressure between the two boilers during operation.

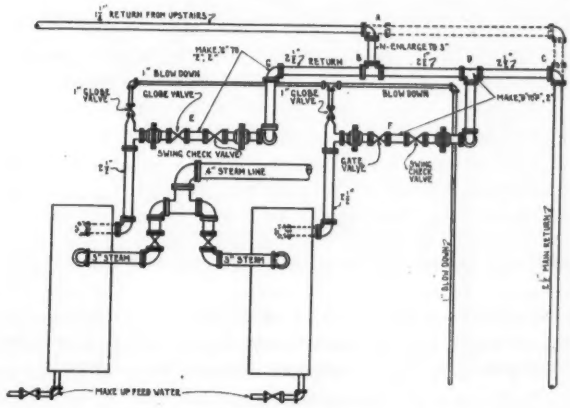
I believe the trouble can be stopped by changing the boiler connecting pipes from 2½ in. to 2 in., up to and including the check valves, which also should be 2-in. valves. The cross-sectional area of 2-in. pipe (nominal diameter taken as before), is 3.1416 sq. in. and the combined area of two such pipes is 6.3 sq. in. approximately. This more nearly agrees with the cross-sectional area of 6.7 sq. in. of the two present return pipes.

It is better for the pipes connecting the boiler to the return header to be smaller in combined area than the area of the header itself, so as to insure both pipes to the boiler being full of water all the time during operation.

Another thing that would help prevent the trouble would be an equalizer, but in installing that, R. B. E. should consult the insurance company inspector or the state inspector in order to find out the existing rules for such equalizers.

Brooklyn, N. Y. CHARLES J. MASON.

In our original reply to R. B. E., which was not published, we suggested blocking off D and connecting the 2½-in. return as shown from C to A. This would send all the returns through N, where they would probably divide



PIPE SIZE SHOULD BE REDUCED WHERE INDICATED AND CONNECTION AC INSTALLED

equally. N would be enlarged to 2½ or 3 in. We believe that if this is done in connection with the change of pipe sizes as directed by Mr. Mason, considerable improvement will result. These changes would, on the whole, involve less expense and fewer changes in the existing installation than any others.

It seems to us that the layout of piping illustrated is awkward and unnecessary and that the expense of rearranging and simplifying it would pay for itself in boiler economy, since the wide variations in water level complained of by R. B. E. cause waste of coal.—Editor.

I HAVE observed with interest R. B. E.'s question in the March 15 issue, concerning the returns to his heating boilers.

In my opinion, the principal cause of this trouble is improper pipe installation. Another factor not to be lost sight of, regardless of how the feed piping is installed, is

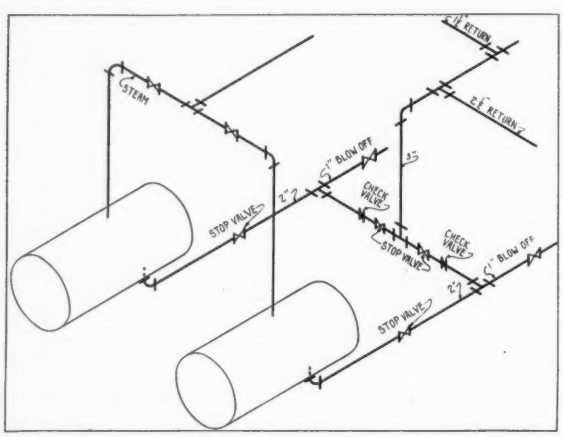
that there will naturally be some difference in furnace temperatures and firing. One boiler may consume more feed water than the other by steaming faster. The same thing may occur if one boiler has less scale than the other, or if the settings of one are in better condition than the other.

Most of the trouble, however, should be removed by the layout shown in the accompanying sketch. When installing this pipe, the tee marked A on the return line should be the starting point. From each side of this tee into each boiler, there should be the same number of fittings and valves and the same lengths of pipes and nipples; otherwise the friction and static heads will be unbalanced and the water will follow the path of least resistance to the boiler.

Below the water level of the boilers, an equalizing line might be installed, with a valve in the middle of it. By opening this valve the water levels can be equalized.

Galveston, Texas. H. W. Rose.

With the connections changed as shown, we suggest that the equalizer will hardly be necessary, since the return connections perform this function. The various hydraulic



RETURNS ARRANGED THUS WOULD EQUALIZE WATER LEVELS

pressures involved would be equalized and we believe the boilers would take the returns equally, provided their rates of evaporation were somewhere near equal.—Editor.

Replying to the inquiry of R. B. E. in the issue of March 15, as to the cause of the apparent trouble with the returns from his heating system, I would like to ask whether he is absolutely sure that there is any trouble at all at this point and whether it is not possible that the fault is at the steam end, instead of at the water end of the boilers. It is perhaps not an exaggeration to state that in about 90 per cent of the cases where erratic water lines have occurred, in heating boilers, the cause has been priming or, perhaps more accurately, foaming.

The first thing that strikes one in glancing at the diagram is that if the boilers are loaded to anything near capacity, the steam outlets may be too small for low pressure service. Presumably the boilers have a capacity of somewhere in the neighborhood of 7000 sq. ft. of radiation each, and 3 in. outlets would be none too large. Then again, while the short tee header might not be objectionable if the steam were dry, if two streams of foam meet head on in this tee, almost anything may happen to the water lines of the boilers.

Newark, N. J. J. O. G. Gibbons.

Figuring Piston Diameter for a Given Cylinder

Under the above heading, in the Feb. 15 issue, page 259, a method of figuring the proper piston diameter for a 42 in. steam engine cylinder was explained. The rule used was that given in Kent's Mechanical Engineers' Handbook.

Several manufacturers of various types of engines have furnished us information as to their practices in figuring piston clearances, and their remarks are given below. It will be noted that there is considerable variation in practice here. But we believe these comments will be of interest to engineers who have occasion to perform engine repairs in their own plants.

One manufacturer stated, without other comment, that the piston for a 42 in. cylinder should have a clearance of 0.018; that is, the piston diameter should be 42—0.018 in. A second company, also without commenting further, remarked that they would make the piston diameter 42—0.026 in.

Comments as follows came from a third company: "We have adopted a rule to make pistons 0.001 in. smaller per inch of cylinder diameter, plus 0.005 in. This would give 0.045 in. clearance on a 40 in. piston.

"This rule is for cast iron pistons or bull rings. If the piston is fitted with rings of anti-friction metal, such as Allan metal, the outside of these rings is turned 0.0015 small for each inch of cylinder diameter, plus 0.005 in. The cast iron part of the piston would be turned about 1/32 in. smaller in diameter, thus leaving these rings projecting about 1/64 in.

"We might also say that this matter is one in which practice is not at all uniform. We have finally settled on the above rules rather arbitrarily, but they seem to work out well in practice, as we have never had a piston stick when made according to these rules.

"In regard to the piston clearance in our uniflow engine cylinders, these rules do not apply. For these engines, we determine the clearance in each individual case to suit steam temperature and other conditions.

"Most of our uniflow engines are fitted with tail rods, the outer end of these rods being carried in crossheads sliding on suitable guides. In engines in which the rod is not cambered to compensate for the deflection, we turn the piston body enough smaller than the cylinder to insure the piston's clearing the cylinder wall at all times."

From a fourth company, the following remarks have been received: "Our standard piston clearance is 0.001 in. per inch of cylinder diameter up to 36 in. Above 36 in., this clearance remains practically constant at 0.036 in., with some additional clearance in case high temperature steam is to be used in cylinders larger than 36 in. In other words, if the rule given in Kent, instead of stopping at 20 in. cylinder diameter, went up to 36 in., or sometimes 40 in., it would practically conform to our practice."

Finally, the practice of a fifth manufacturer is reported as follows:

"On counterflow engines, our practice is to allow clearance of 0.001 in. per in. of cylinder diameter. This value holds throughout our range of sizes. Cylinder diameters above 30 in. are not common with us; but where they have been used, this same clearance allowance has been satisfactory. It may be well to note also that our pistons are regularly equipped with bearing rings of anti-friction metal, projecting above the cast-iron surface, and that the

piston diameter is measured over these bearing rings. Cylinders are bored nominal size; the pistons are turned smaller the proper amount.

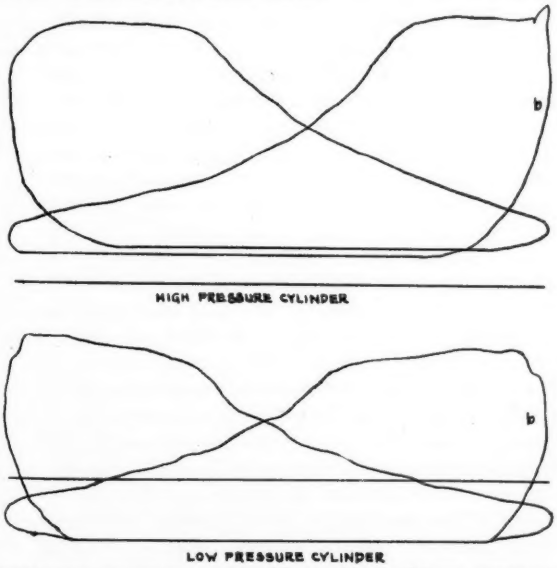
"A calculation of expansion of the piston alone would make these clearances sometimes seem too small, and for iron to iron contact they might be, but, in service, the cylinder bore will also be subject to practically the same temperature change as is the piston diameter, and would change in size at somewhere near the same rate.

"In uniflow engines, where pistons and cylinders are much longer in proportion to the bore than on counterflows, and the temperature range between ends and center is greater, due to the center exhaust, we allow 0.0015 in. per in. of diameter. Due to this same temperature difference, cylinders are bored slightly barrel shaped and pistons are turned smaller at the ends, when cold, so that both may be, as nearly as possible, true cylinders when hot."

Kent's rule, referred to above, states that the clearance should be 0.001 in. per in. of cylinder diameter up to 20 in. cylinder diameter. Above 20 in. diameter the clearance should be 0.0005 in. for each additional inch above 20.

Indicator Diagrams Show Faulty Steam Lines

PLEASE COMMENT on these diagrams from a 2200-hp. vertical cross compound engine, size 30 by 60 by 36 in. running at 145 r.p.m. What causes the excessive rounding on one of the high pressure cards? J. J. C.



INDICATOR DIAGRAMS FROM 30 BY 60 BY 36-IN. VERTICAL CROSS COMPOUND ENGINE

A. Since there is no marking on these diagrams to designate which is the head end and which the crank end card, we shall designate the left-hand end by a and the right-hand end by b.

The rounding on the admission line of card is excessive, probably caused by the fact that admission appears to be late. We notice also that the steam line of card a is not as high as that of card b and the exhaust line is higher. Just what causes this we cannot say, as you do not tell us the type of valves on this engine. Possibly the port opening is not large enough or the valve does not open fully. This condition might occur with single ported valves.

On card b of the high pressure diagram, the slight peak on the admission line is caused by the fact that there is too much compression, with the result that when steam is admitted, the combined pressure of the entering steam and the compressed steam rises for an instant above the steam chest pressure and then falls as the stroke begins. By reducing the compression on this end of the high-pressure cylinder and by making admission a little earlier, you can secure a better admission line as this point. The other events on both ends of this cylinder are probably as near to the theoretical condition as you can get them.

On the low-pressure diagram, the principal defect is caused by late admission on each end. The vertical part of the admission line leans inward on each end and there is a decided hook in this line just before the valve is fully opened, which probably marks the dead center position of the piston just as it starts on the return stroke. It is possible that there is not quite enough steam lead on the valve. In any case, make admission come earlier. Aside from this, the other events of the card seem to be located fairly well.

The steam line on the low-pressure diagram slopes more than it should, but whether you can correct this or not is a question. It is possible that your receiver is not big enough and that your high piston speed of 850 ft. per min. causes some wiredrawing during admission, thus causing some drop in pressure.

Strength of Cast-Iron Pipe Fittings

PLEASE give me some figures on the bursting strength and the safe working pressure of cast-iron pipe fittings, both standard and extra heavy. D. A. L.

A. Most of the information you wish is given in the catalog of a large company whose figures are often used as standards by engineers and designers. This company states that the gray iron which it uses in its cast-iron fittings has an average tensile strength of from 22,500 to 25,000 lb. per sq. in. It states further that its standard wedge gate valves with iron body, sizes 4 to 8 in., will burst under hydraulic pressures of from 1000 to 1500 lb. per sq. in. These gate valves are ordinarily specified for steam working pressures up to 125 lb. and for water working pressures up to 175 lb. Standard flat band screwed fittings made of cast iron have broken under test when subjected to hydraulic pressures of from 1000 to 2500 lb. per sq. in., according to the size and fittings. Extra heavy cast iron flanged fittings, in sizes from 6 to 24 in., have an average bursting pressure of 1263 lb. per sq. in.

This company has also called attention to the fact that the form of fitting is a determining factor in its bursting strength. To demonstrate this, they selected certain fittings of a given size and subjected them to hydraulic pressure to destruction. It was found that long turn elbows burst at 2800 lb. per sq. in.; straight elbows at 2400 lb.; reducing tees, 1700; reducing laterals, 1500 and straight laterals, 800 lb. per sq. in.

It was found that the strength of elbows is practically the same, regardless of the degree or whether they are straight or reducing. It was also found that fittings of the same general shape as the tee, or cross, were of nearly the same strength and have relatively about two-thirds the strength of fittings of the elbow shape. It was noticeable that the straight lateral is weak, having, in fact, only about one-third the strength of the elbow shape.

EDITORIAL COMMENT

Turbine Design

Limitations imposed upon the design and construction of steam turbines are based primarily upon two practical considerations, the one being that of the expense justified to obtain more economical and greater output and the other being that of the limitations of the physical properties of the materials available for their construction.

Twenty-five years ago a water rate of 20 lb. per kw-hr. was considered good. Since that time, however, that figure has been more than cut in half. First efforts at reducing the water rate were put into practice without an unwarranted increase in the cost of manufacture, but later efforts have resulted in greatly increasing cost. In some instances, engineers are prepared and willing to make the necessary additional expenditure for extremely high-efficiency units in order to obtain a high-efficiency plant. In the great majority of cases, contracts go to the lowest bidder, penalties for failure to meet guarantees are not enforced by the buyer and, therefore, commercial considerations have been the determining factor. In some cases this latter method may be justified. The question may readily be raised, however, as to whether or not buying instinct is allowed to overrule sound engineering judgment.

During the last few years there has been a decided trend towards the use of increased steam pressures and temperatures. The changes in design necessary to meet an increased pressure do not involve anywhere near the difficulties arising from the use of temperatures above a certain limit. Steam pressures for use in turbines seem to have come to rest, at least for the moment, at approximately 1200 lb. per sq. in. as the top limit.

The problem involved in establishing the upper limit of the temperature range is more definite than that for pressure because of the sharp changes in physical properties which take place in a metal when subjected to certain temperatures. Investigations carried on during the past few years have added materially to our knowledge of the effect of temperature upon physical properties. Many investigations have not disclosed, however, the extreme importance of the duration of the test.

It has recently been shown that a steel which failed in but a few seconds at a temperature of 1500 deg F., failed under the same load in about 28 hr. when the temperature was maintained at approximately 25 per cent less than that of the first test. The importance of this finding must not be underestimated, for it has shown that at higher temperatures the fatigue limit of a steel may be actually greater than its static breaking stress. These observations have, of course, been made at temperatures somewhat above the accepted temperature limit of present day practice. They do appear, however, under the light of present knowledge, to restrict steam temperatures, at least for the present, to an upper limit of about 900 deg. F. It is conceivable that this limit may be raised, later, through the employment of alloys which are now undergoing a thorough examination as to their physical properties.

Morale of Operating Force Affects Power Cost

On many occasions, we have pointed out that economical operation of a power plant depends as much upon the efficiency of the operating force as it does upon the efficiency of the machinery they operate. This human efficiency depends, in turn, upon a certain intangible but none the less powerful spirit in the organization which we call morale. It is a kind of loyalty, a feeling somewhat akin to patriotism, that makes each man in the organization proud of his job, anxious to do his work to the best of his ability, confident that, if he has ability, it will receive recognition in either promotion or increased wages and, in general, makes him glad to work for that particular company.

We have seen, however, too many plants in which this high morale is conspicuous by its absence. Wherever morale is low, extreme dissatisfaction will often be found as the cause of the trouble. This dissatisfaction usually has at its roots contempt for a manager or chief engineer who uses poor judgment in the assignment of work, who plays favorites, who shows that he lacks confidence in his men or who is constantly nagging them and hedging them about with petty rules and regulations. Then, too, when a workman feels that, no matter how well he does his work, he will never secure recognition by either increased pay or promotion, he will react in a perfectly human way, either by getting another job or by loafing on his present one.

In a certain power plant we visited recently, the high morale of the men was the thing found most interesting. Only an occasional piece of the plant equipment was new or unusual, yet the economy of the plant was good. Every man was taking a personal interest, not only in his particular job but also in the overall operation. On a large bulletin board in the boiler room was posted a table of operating costs for the previous month, subdivided into departmental costs, just as they appeared on the chief engineer's office records. Beside this was the corresponding record of the power plant costs of another plant operated by the same company. And every man in one plant was on his toes to make a better record than that of the other plant. One of the firemen in this plant remarked, "The boys will do anything in the world for the chief. He treats us like men. We know he is giving us a square deal."

Every man in that power plant organization had access to the same information that the chief used in running the plant. If the cost of power went up in one department, everybody knew just where the trouble was and usually the man responsible for it was the first one to suggest methods for removing the cause. The men were doing their best to beat the competing plant; they knew that if they did, recognition was sure to come.

This little example of high morale interested us because it is rather unusual. It takes time to build up morale in any organization. It needs, most of all, a chief engineer

or a plant manager who has the proper personality, the proper engineering ability and the proper knowledge of men to do it. But it pays dividends. High morale in the operating force means high efficiency, with the final result that every man will be helping to generate power at the lowest possible cost.

High Load Factor Is Secured by Coordination

One of the most common complaints of the power plant engineer in industrial plants is that the power and steam which he has produced is used in the various departments of the factory without any thought of economy. When the subject is brought up for discussion with the foremen he is usually told that his responsibility ends with the production of the power and steam and to see that he has plenty available at all times.

In most organizations his responsibility does end with the power plant but to get the greatest value out of the power plant services some method of coordinating the work of the various departments with that of the power plant is necessary. Mr. Burke has shown, on other pages of this issue, how, by the provision of a power despatcher, this was accomplished in a textile mill with considerable saving in the cost of operating the power plant. When we consider the various ways in which the services of the power plant are used in almost any industrial plant, a power despatcher seems just as necessary in the industrial organization to prevent jamming of the power system as a train despatcher is to the railroad system.

Off Duty

It's a busy little world we're living in these days and men are doing all sorts of queer things—things which 200 yr. back would have been regarded as witchcraft of the most damnable kind. Imagine, if you can, what would have happened to a man in old Salem who spent his time hatching fruit flies in a milk bottle and then proceeded to formulate laws regarding the lives of human beings, or to a man who made pipe stems and knitting needles out of carbolic acid. We don't have to imagine. Before the grandchildren of the first batch of fruit flies were old enough to recognize a green banana, the kind hearted people of Salem would have tied the good man to a post in the village square and converted him into the familiar products of combustion.

But the world is going backwards, many people tell us, and we don't do anything like that any more. We are becoming hardened and everybody is going to the dogs. We not only permit the fruit fly breeder to live but actually encourage him in his devilish activities. We do strange things ourselves. Coming home from our work at night instead of behaving like respectable folk we climb up on the roof, stretch a piece of wire across the house and then proceed to pull "hot mamma" music out of nowhere. Strange doings—strange music. Imagine Cotton Mather building a reflex set in the cellar of his Salem bungalow!

Speaking of queer doings reminds us of a queer stunt they are pulling off over in Quincy, Mass., not very far from Salem of witchcraft fame. It is especially interesting to us because it has something to do with a power plant—quite a good sized plant, one of 135,000 kw. in fact.

Before we go any further, however, let us picture in our minds, an airplane field. This sounds silly; but then, we can't always be serious. Imagine an airplane field and also a 135,000-kw. electric power plant. Draw a picture of them if you like.

Now take your airplane field and (here's where you can exercise your mechanical ingenuity) mount it firmly on top of your power plant. Impossible, you say? Of course it's impossible and that probably is the reason they have done it out in Quincy. People are always doing impossible things. In fact, in Quincy, not content with building an airplane field on top of a power plant, they took the whole "shootin' match" and put it on a raft. This raft, or airplane carrier as it is called, can cut a groove in the surface of the Atlantic at the rate of 38 mi. an hour.

They have made two of these amazing vessels in the East. The first, the U. S. S. Saratoga, was launched April 7 in Camden, N. J., and the second, the U. S. S. Lexington, will be launched in the fall at Quincy, Mass. They are the longest naval craft in the world, and are more powerful and faster than even the U. S. S. Maryland and West Virginia, the most powerful battleships in the world.

The power plant of the Saratoga is quite an affair. When doing 33 knots it is capable of developing 180,000 hp. or 135,000 kw. This is greater than the combined output of the six electrically-driven ships now in commission, the "New Mexico," "California," "Tennessee," "Maryland," "Colorado" and the "West Virginia." The propulsion machinery consists of four 35,200 kw. G. E. turbogenerators, supplying current to eight 22,500-hp. motors. Steam is furnished by 16 oil-fired boilers. In addition to the power used for propulsion, electric current is needed for other purposes. This, however, is an insignificant item, and the six d.c. auxiliary turbo generators installed for the purpose generate a miserable 4500 kw.

By this time you will have begun to perceive that the Saratoga is "some boat." We poor apostles of common sense know what a 135,000-kw. plant looks like, but to ask us to shove such a plant into the hull of a vessel is asking too much. This ship could tie up to the dock at a city the size of Cincinnati, throw a cable over the side and run the entire electrical load of the city.

Shades of John Paul Jones, the Spanish Armada and Noah's Ark, what are we coming to! They called the Monitor a cheese box on a raft—what would they call this? Imagine the Leviathan, Hell Gate Station and Mineola Flying Field superimposed on each other plowing the North Atlantic at 33 knots! It's enough to make Father Neptune give up his job and take up farming in Mid-Nebraska.

The Saratoga is different from anything ever built. Even the smoke stacks have had to relinquish their time worn location in the center of the vessel and have had to accept an ignominious place off to one side of the deck which is so immense that it resembles a marine drill ground. The ship is 4406 ft. less than a mile long and has a beam of 105 ft. Its speed is somewhat less than that of a Ford running wild, or somewhere in the neighborhood of 33 knots. This is 12.6 knots faster than the Maryland.

And, by the way, we almost forgot to mention it, the ship also has a mast, not much for a ship of this size to boast about, but extremely necessary for it carries the aerial to the radio equipment. This mast is so high that in going up the East River they will either have to lower the mast or else raise the Brooklyn Bridge. We understand, however, that the Navy Department has provided for lowering the mast.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Load Indicator Compensates for Ambient Temperature

IN THE operation of distribution transformers, it has always been a difficult matter to keep reliably informed as to the load on the transformer. In order to provide a practical means for determining this, the General Electric Co., of Schenectady, N. Y., has recently placed on the market a load indicating device which compensates for ambient temperature. The device is known as the Type A Thermotel.

THE DIAL TYPE THERMOTEL. (TRANSFORMER LOAD INDICATOR) SEMAPHORE TRIPPED. INDICATING HAND REGISTERING OVERLOAD

This instrument consists fundamentally of two thermometers connected in series. The first thermometer is actuated by the heat of the transformer's top oil; the second, located in the external case, by the ambient temperature and modifies the reading of the first. The composite reading given by the hand closely approximates the internal coil or hot spot temperature and, for convenience, is given in terms of "per cent equivalent load." This is the percentage of the safe continuous output of the transformer, represented by the load cycle causing the indication. The dial is calibrated from 50 to 125 per cent equivalent load, indicating either underloaded or overloaded transformers. A semaphore is tripped by the mechanism, and swings into view when the instrument registers more than 100 per cent, equivalent load. Readings in excess of 100 per cent show that the transformer is too small since it has carried a continuous load, or a short time overload equivalent to a continuous load sufficient to bring the internal winding temperature (hot spot) to 100 deg. C. or higher. A re-setting lever extends below the external case and, upon being re-set, the instrument indicates the then existing load conditions on the transformer.

Other important features of this instrument are the ease with which it is installed, it being necessary only to lift the cover and slip the supporting arm over the edge of the tank, and the ambient correction which takes into account all variations in ambient temperature. It is suitable for use on wide ranges of 60-cycle, pole type, distribution transformers.

Studies in the Correlation of Coal Beds

RESULTS of a study of the correlation of coal beds of the Allegheny formation of western Pennsylvania and eastern Ohio are given in Bulletin 10, just published by the Carnegie Institute of Technology, Pittsburgh, Pa., in the course of a co-operative agreement with the Department of the Interior. The correlation of coal beds, or their identification in one or more states or in several districts of one state, is of practical value to the coal operator and coal dealer, as by this means they are able to state definitely from which bed their coal comes.

In every part of the Northern Appalachian coal field, as well as in other fields, there exists a need for exact correlation of the coal beds. Confusion is caused by the fact that the beds are given a great variety of local names, and because official geological surveys have not used the same nomenclature for beds known to be the same. In some localities, coal operators do not know what bed they are mining, and the coal buyer or consumer often has no check on the source of his coal.

Work on correlation of coal beds has been done in western Pennsylvania and eastern Ohio by State and Federal geological surveys employing stratigraphic and paleontological methods. During the past three years the Bureau of Mines of the Interior Department, through Reinhardt Thiessen, research chemist, and the Carnegie Institute of Technology, through a fellowship in charge of Mr. Thiessen, have been correlating coal beds by means of a microscopic study of the spores in the coals. In 1923 the beds in the Monongahela formation in western Pennsylvania, eastern Ohio, and western Virginia, were correlated; and in 1924 the Allegheny formation in western Pennsylvania

and eastern Ohio was studied. Samples of coal were obtained from 38 mines in Pennsylvania and Ohio, and the coals were first examined visually and then microscopically when prepared in thin sections. The coals were from the Lower, Middle, and Upper Kittanning beds, and the Lower and Upper Freeport beds. As a result of this investigation it has been possible to correlate each bed by means of spores and other structures found therein. Distinct spore forms were observed in the coal of the five beds examined, even as much as 100 mi. apart in the Lower Kittanning bed. These spores are described, provisionally named, and illustrated in Bulletin 10, copies of which may be obtained from the Carnegie Institute of Technology, Pittsburgh, Pa., or from the Department of the Interior, Bureau of Mines, Washington, D. C.

Maine Bill Proposes State Power Business

THAT THE State of Maine may enter into the power business and break the constitutional prohibition against the sale of power manufactured within the state to parties outside the state, is part of the subject matter of a bill introduced in the Maine Legislature by Representative Norwood, of Warren, Me.

While the bill as submitted may be opposed by some of the Maine power companies as it is now worded, in that it might tend to deprive them of certain rights for the manufacture and sale of hydroelectric power, it is believed that if provision is made to protect their rights, they will offer no opposition to the generation of hydroelectric power for sale outside the state or to such sections of the state as are not now served by existing power companies.

In the recent extensive survey made by New England power interests and engineers and published some months ago in Power Plant Engineering, it was pointed out that the undeveloped resources for generation of electricity by water power in Maine alone would supply all of the requirements of New England for some years to come and would greatly decrease the cost of power to consumers, but that under existing laws such work was impossible as the state's constitution prohibited the export of power manufactured within the state.

While not specifically making provision for the repeal of that part of the state's constitution, the bill of Representative Norwood implies that such a course would be taken. The bill provides for the appointment by the governor of three power trustees, who would have title to all of the power resources available for the generation of hydroelectric current on all inland streams and waterways now owned by the state, which includes the St. John River project.

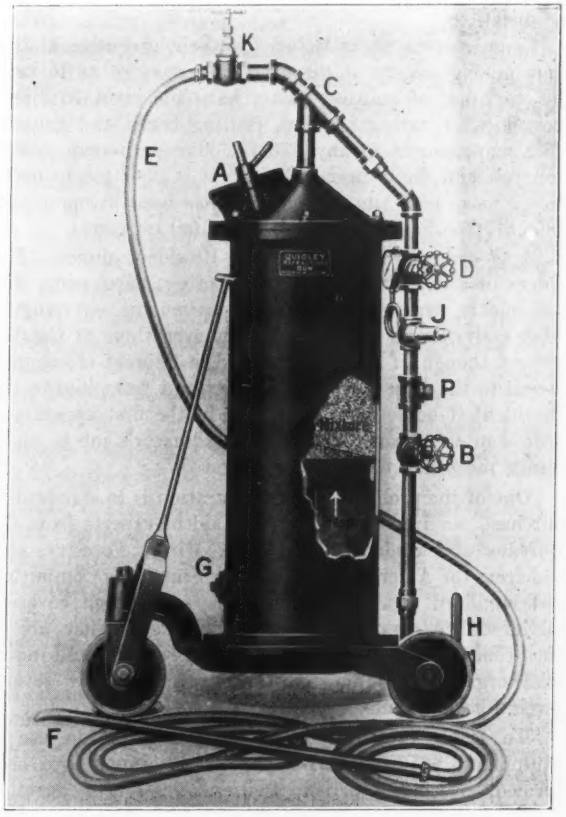
This project is looked upon in New England as probably the most important undeveloped waterway for generation of hydroelectric energy in the East, capable of providing sufficient current to supply all present needs of New England without other sources of supply being touched.

The bill further provides that the trustees shall have full power to develop these resources "for the sale and distribution of such energy in the interest of all of the people of the State." It provides for a comprehensive power survey and shall submit a report on the same on or before Jan. 15, 1927, together with recommendations and plans for its distribution and an estimate of the cost of such work. An appropriation of $10,000 is made by the bill for use of the trustees in making such a survey and report.

Refractory Gun for Lining Furnaces

RELINING, patching or surfacing furnace walls with speed and at low cost, is being accomplished by the use of a new refractory gun which is operated by compressed air. Pre-mixed refractory material is placed in the gun. The nozzle is then pointed at the place to be repaired and the gun operator, by handling the valve controls, forces through a section of hose to the nozzle where the repair man makes the application.

Air pressure required will vary from 90 to 100 lb., depending on the nature of the material. For heavy plastic mixtures, pressure from 95 to 100 lb. is used, and



PRE-MIXED REFRACTORY MATERIAL IS PLACED IN THE GUN

for thin mixtures work has been done at a pressure as low as 50 lb. As the illustration shows, the gun consists of a cast-iron cylinder from which the material is forced by pressure applied to the piston. Pre-mixed plastic material is placed in the gun through a charging opening (A) in the top. Pressure is applied at the bottom of a piston, through pipe connection P, and controlled by valve B. As the piston rises, the mixture is forced into the Y connection C from which point it is carried through the hose to the nozzle by the combined pressure of the piston and pressure through the air control valve D. A drain plug G is provided just above the piston and a quick opening cock for releasing the pressure under the piston at H. When the gun is emptied the cock H is opened and the piston returns to its former position. The gun is then ready for refilling. It has a pressure gage and pop safety valve at J.

This gun has a capacity of 2 cu. ft. of mixed material. It is mounted on three wheels and can be easily moved from place to place around the plant. The gun when not required for furnace repair work can be used about the plant for rough white-washing, spraying paint or handling plastic mixtures such as stucco. It is manufactured by Quigley Furnace Specialties Co., New York, N. Y.

Government Business Adopts Economy

BUSINESS is being introduced into the administration of the government departments more than is generally realized. In fact, in some respects, the methods are becoming more businesslike than those of many private organizations.

Co-ordinators are selected for their executive ability from among officers of the army and navy so as to keep the work out of politics. They have the right to direct economies in buying supplies, routing traffic and general office management in any Federal office or bureau except Congress and the Supreme Court. It is their job to make things move and, since the system has been in operation, $865,517,155 has been cut out of annual estimates.

A co-ordinator represents the President direct. His orders in a department as to accounting, purchasing, disbursements, arranging publicity, warehousing, shipping or other activities take precedence over even those of Cabinet officers, though, if he feel aggrieved, a Cabinet officer may appeal to the Director of the Budget and from him to the President if he acts within 4 days in the first appeal and 6 days in the second. It's the co-ordinator's job to make things move and delay is not tolerated.

One of the problems in administration is to standardize purchase requirements. With the aid of experts from the Bureaus of Standards, Chemistry, Mines, Forestry, etc., and from the American Engineering Standards Committee, 184 standard specifications have been prepared covering all important commodities in the market. They are so good that they are being adopted by cities, states and industrial organizations and have been requested by several foreign governments.

To secure cooperation in purchasing and in use of equipment, 86 Federal Business Associations have been formed, covering 90 principal cities. These bring together executive heads of local departments and offices to discuss their needs and problems. If the post office needs trucks and the local arsenal has idle trucks, those trucks haul mail. When the post office wanted tank cars so that it could save by purchasing gasoline in Philadelphia, they were loaned by the War Department and later the post office delivered gasoline to Frankford Arsenal so that it might retain the cars.

No economy is too small to be overlooked; 13 listings of one Philadelphia office in the telephone directory at 25 cents each were cut out, together with enough others to save $300 a year. Saving old twine in the printing office amounted to $1000 a year. Washing and reusing waste rags saved $1160 in a year. Horses of forest rangers were wintered at a distance from headquarters where hay cost $5.00 a ton rather than in the city where it cost $15. And so it goes in all departments.

As President Coolidge said in a recent address, some call it "cheeseparing" but nobody is kicking about the reduction of taxes which the saving of $865,500,000 by such economies has made possible. Perhaps "business" may yet have to go to the government to learn how to practice economy.

Licenses and Permits Issued by Federal Power Commission

A LICENSE for fifty years was issued by the Federal Power Commission to the Washington Irrigation & Development Co. for a project at Priest Rapids on the Columbia River, Wash. The initial installation will develop about 34,000 hp. with provision made for an ultimate installation of about 750,000 hp. The head formed by the dam to be built will be approximately 78 ft.

Joint license has been given the Portland Electric Power Co. and Crown-Willamette Paper Co. for a power project on the Willamette River in the vicinity of Oregon City, Ore. The license covers a modification and extension of an earlier development and the new extension will increase the capacity of the plant by about 7200 hp.

Preliminary permit for three years has been given to the Gauley Power Co., covering a proposed development on Gauley and Meadow Rivers in West Virginia, involving six dams on the Gauley River and four on Meadow River, in addition to several storage dams. The total capacity of the project will be about 55,000 hp.

A preliminary permit has been secured by the El Dorado Power Co. covering a project at China Flats on the Silver Fork of the South Fork of American River, El Dorado County, California. The power capacity of the entire project will be about 7000 hp.

The Power Commission has also issued a preliminary permit to the Southern Colorado Power Co. for a development on Grape Creek, a tributary to the Arkansas River, in Fremont and Custer counties, Colorado. The project calls for the construction of two dams, at one of which 7500 hp. will be generated under a head of 900 ft. and at the other 6000 hp. will be generated, the head being 700 ft.

The Interstate Public Service Co. has secured a preliminary permit from the commission covering a project in St. Joseph River in Northern Indiana and Southern Michigan. The dam is proposed near Bristol, which will permit the construction of a plant of 4200-hp. capacity.

Los Angeles Has Largest Ice Machine

WHAT IS reported to be the largest direct connected, electrically driven, two-stage ice machine in the world was recently installed in the plant of the Los Angeles Ice & Cold Storage Co. by the Carbondale Machine Co. This 700 T. refrigerating machine is driven by an 800 hp., 2200-v., three-phase, 50-cycle General Electric synchronous motor. The compressor is a Carbondale-Worthington feather valve, two-stage type with a low-pressure cylinder 26 in. in diameter with a 30-in. stroke and a high pressure cylinder 16½ in. in diameter with a 30-in. stroke. The machine operates at a speed of 150 r.p.m. and has a refrigerating duty equal to the melting of 700 T. of ice each 24 hr. when operating at a pressure of 20 lb. suction and a condensing pressure of 170 lb. Between the two cylinders is placed an intercooler of the Spira Flo type for the purpose of cooling the discharge gas from the low pressure cylinder before it is admitted into the suction of the high pressure cylinder.

In spite of its large capacity, the complete unit occupies a floor space of but 400 sq. ft. It is now doing the work previously done by four slow speed compressors occupying a total floor space of 3200 sq. ft., or eight times that occupied by the new unit. At the present time the machine is carrying the cold storage and ice making load of the plant and, in addition, is supplying refrigeration service through three miles of pipe line to more than 100 customers, including hotels, cafes, markets, etc., in the retail district of Los Angeles.

Jacket Water Cooler Uses Any Raw Water Supply

OIL AND GAS engine and compressor operators, and especially those who have been troubled by scale formation in engine jackets, or excessive oil consumption, sticking piston rings, cylinder scoring and the other evils arising from overheated cylinders, will be interested in the G-R Jacket water cooler, recently put on the market by the Griscom-Russell Co., of New York.

G-R JACKET WATER COOLER

This apparatus uses any source of raw water supply to cool the circulating water supply. A small amount of distilled water can therefore be continuously circulated through the jackets and the shell space of the cooler in a closed system, being cooled by the raw water passing through the cooler tubes.

Besides being highly efficient in its cooling action, this apparatus is particularly compact, and constructed so as to permit easy inspection and cleaning. A removable tube bundle comprising a continuous helical baffle of sheet metal formed around a central core tube with tubes inserted through holes in these baffles, all contained in a bored shell of close grain cast iron. One tube sheet is stationary and the other is part of a floating head designed to accommodate expansion movement of the tubes.

Water Columns at Montaup

IN THE ISSUE of April 1, the list of apparatus of the plant of the Montaup Electric Co. showed the water columns as being Stets. This was an error, as the water columns for this plant were Williams columns, furnished by the Williams Gauge Co. of Pittsburgh.

News Notes

CONTRACT has been awarded to Stone & Webster, Inc., Boston, by the Manchester Traction, Light & Power Company, with headquarters at Manchester, N. H., for an extension of the boiler house of its existing steam station at Kelley's Falls, which has an installed capacity of 18,750 kw. The boiler house building will be enlarged and a 1495 hp. Babcock & Wilcox Company boiler will be installed with a feed-water heater and the necessary auxiliaries.

AT THE FOURTH national exposition of power and mechanical engineering apparatus and equipment, to be held in Grand Central Palace, N. Y., Nov. 30 to Dec. 5, 1925, heating and ventilating equipment will form one of the large sections. It is reported that ninety-five firms have already contracted for space in which to display forced draft equipment, heating devices, ventilating equipment, temperature regulators and instruments and fittings used in heating and ventilating installations.

THE C. J. TAGLIABUE MFG. CO., Brooklyn, N. Y., announces the creation of an engineering research department which is to study the requirements for automatic control and other problems in various industries. This department will be headed by Victor Wichum, who continues as chief engineer.

THE RILEY STOKER CORPORATION announces that G. H. Sanger has been transferred from the Philadelphia office to the Chicago office of the company; also that the Mine & Smelter Supply Co., of Denver, Colo., has been appointed representative for the Denver and Salt Lake territory.

NORRIS R. SIBLEY, formerly with the Westinghouse Electric & Mfg. Co., has recently joined the B. F. Sturtevant Co. in its sales organization. Mr. Sibley is located in the New York office of the company and has charge of steam turbine sales in that district.

J. J. MULLAN & Co., New York City, and H. H. Leathers, Boston, Mass., have recently been appointed representatives in their respective districts for the Moore Steam Turbine Corporation of Wellsville, N. Y.

STANDARD TURBINE CORPORATION, Scio, New York, has recently appointed the Hale-Stephan Co., Cleveland, Ohio, as district representative.

CARROLL H. MOUNT has resigned his position with Stearns Conveyor Co. at Cleveland to accept appointment as sales engineer for Jeffrey Mfg. Co. in that city.

AT THE ANNUAL meeting of its Board of Directors, the Erie City Iron Works of Erie, Pa., made several changes in its personnel. Hays H. Clemens, treasurer of the Hays Manufacturing Co. and director in the Kalbfleish Corporation and the National Manufacturers Association, was elected president to succeed Edward C. Moore, who remains with the company as vice-president and treasurer. L. V. Reese, general manager of the company, was elected secretary and will hold that office in addition to his present duties. A. R. Horr, vice-president of the Cleveland Trust Co. and Ely Griswold, vice-president of the Griswold Manufacturing Co. of Erie, together with the officers previously named, complete the board of directors of this company.

CLARENCE HERBERT SANDERSON, of the engineering staff of the New York Edison Co., has been appointed Assistant Electrical Engineer of that company, succeeding R. H. Hapscott, who has assumed the duties of Electrical Engineer. Mr. Sanderson entered the employ of the New York Edison Co. in 1920. He was given the position of Assistant to the Chief Electrical Engineer and his work covered specifications, design, purchasing, and the supervision of operation, maintenance, and repairs. He came to New York from the Havana Electric Railway, Light and Power Co., where as Chief Electrical Engineer, and later Assistant Chief Engineer, he installed a 50,000-kv.a. steam turbine plant, and reorganized and modernized the majority of that company's technical departments. For ten years

prior to joining the Havana Company, Mr. Sanderson was in the engineering department of the Westinghouse Electric & Manufacturing Co., specializing in switchboard and power station design.

THE THOMAS FRUIT CO. at Joplin, Mo., is installing three 100-hp. Ingersoll-Rand airless solid injection Diesel engines which are direct connected to 65-T. compressors. The plant will be completed by April 15.

THE BABCOCK AND WILCOX CO. recently announced that Dr. Charles E. Lucke, Professor of Mechanical Engineering and head of the Department of Mechanical Engineering at Columbia University, has been retained as consultant by this company.

SKETCHES HAVE been made for a power plant on Lawrence St., Lowell, Mass., for the Wamesit Power Co., 17 Glidden Bldg., Lowell, to cost approximately $1,000,000. Stone & Webster, Inc., of 147 Milk St., Boston, are the engineers and contractors.

THE CITY LIGHT & WATER CO., of Osawatomie, Kan., is installing a forced draft stoker manufactured by the Illinois Stoker Co. The stoker will be used on a 250-hp. Murray boiler and the other two 150-hp. Brownell boilers will be fired with gas and oil. A new boiler is to be added to this plant this summer.

THE NATIONAL ELECTRIC POWER CO., of Portland, Me., has been authorized under Maine laws to generate electricity, with a capital set at $6,000,000 in preferred stock, and 160,000 shares of common stock of no stated par value. M. F. Foster, of South Portland, is president and M. G. O'Neill, of Portland, treasurer of the new company.

WILLIAM PESTELL has been made a Vice-President of the Riley Stoker Corporation, Worcester, Mass. Mr. Pestell has had charge of mechanical and electrical equipment for the Lynn & Boston R. R. Co., Lynn, Mass.; Worcester Consolidated St. Ry. Co., Worcester, Mass.; United Electric Ry. Co., Providence, R. I.; Allis-Chalmers Mfg. Co., Boston, Mass., also spent several years as a mechanical engineer for the J. G. White Engineering Corp. He has been connected with the sales of Riley stokers from the start of the company, first as western sales manager with headquarters at Chicago, and since 1921, as sales manager with headquarters at New York and Worcester, Mass. As Vice-President, Mr. Pestell will continue to have supervision of all sales for the Riley Stoker Corporation.

THE CENTRAL MAINE POWER CO., of Portland and Lewiston, Me., has purchased from the Union Water Power Co., of Lewiston, Me., all of its rights and privileges in Clark's Rips, one of the largest of the undeveloped power privileges in the state. Plans have been prepared for initial development of this project, involving the construction of a dam giving a 43-ft. head at Gulf Site, about five miles north of Lewiston. This would provide for 10,000 hp. current to replace steam power now required by Lewiston and nearby mills. The Central Maine Power Co. has already linked up its lines so that the new power could easily be distributed to other points in the eastern and western parts of the state when required. Should the Central Maine Power Co. acquire further rights in the river up to Livermore Falls, it could readily produce 50,000 hp. by building a dam of 79-ft. head at Gulf Site.

THE FARMINGTON RIVER POWER CO., of New Britain, Conn., has ordered electric generating equipment for a new station to be erected on the Farmington River about 10 mi. from Hartford. Two 5000-kv.a., 150-r.p.m., 2300-v. vertical waterwheel-driven generators with direct-connected exciters have been ordered from the General Electric Co., together with seven 1667-kv.a., 66,000-v., self-cooled transformers and complete automatic switching equipment. Seven 1667-kv.a. step-down transformers and switching equipment were also ordered for use in a substation in New Britain. The automatic switching equipment is to be similar to that now installed in the Searsburg plant of the New England Power Co.

Book Reviews

STEAM POWER PLANT ENGINEERING. By G. F. Gebhardt. 1036 pages, 5½ by 8 in., cloth; sixth edition, New York, N. Y., 1925. Price, $6 net.

Thorough revision of this well-known book has been made to bring it into accord with present practice. Subject matter has been increased and rearranged to make the book more convenient.

This volume is a thorough treatment of American steam plant practice covering apparatus from that for the elementary plant up to turbines, condensers and comprehensive fuel handling and piping for the most extensive installations. It deals with elements of plant and how they are related to the plant economy rather than with the plant as a whole but shows how and where each element fits in and its relation to other elements.

To show the range of subjects, chapters are devoted to Combustion Boilers, Superheaters, Furnaces and Stokers, Fuel and Ash Systems, Chimneys, Mechanical Draft, Engines, Turbines, Feedwater, Pumps, Separators and Drains, Piping, Lubrication, Testing, Finance. Brief treatment is given of applied thermodynamics and properties of steam and air.

As has been stated before, this book is of such value that no engineer's library is complete without it; the student will find it invaluable as an introduction to the field and the experienced engineer as a convenient reference. The chapter on Finance and Economics—Cost of Power is a particularly thorough and painstaking treatment of this important subject.

CONNECTING INDUCTION MOTORS, by A. M. Dudley; 361 pages, 6 by 9 in., cloth; second edition; New York, N. Y., 1925. Price, $3.00.

This book represents the practical application of a designing engineer's experience to the problems of operating engineers, armature winders and repair men. Beginning with a simple explanation of the induction motor and its principle of operation, it launches directly into a discussion of various types of windings. The material which follows can best be described, perhaps, by listing the chapter headings. These are, in the order of their appearance, Rotor windings, Single-phase windings, Chorded windings, Distribution factor and its use in winding stators of induction motors, Effect of voltage on windings and possibility of connecting a winding for more than one voltage, How number of phases affects windings, How frequency affects windings, Number of poles and r.p.m. and possibility of varying them with the same winding, Less common connections used for unsymmetrical conditions or in an emergency. Reconnecting an old winding for new conditions, Locating faults in induction motor windings, How to figure a new winding for an old core, Connecting to

correct side pull, Standard group diagrams from 2 to 14 poles, Lap windings with unequal coil groupings, Wave diagrams.

Since the first edition appeared in 1920, this book has been considerably enlarged, having 361 pages against 252 in the 1920 edition.

"The Effect of Temperature Upon the Properties of Metals," 134 pages, paper cover, has recently been reprinted from the proceedings of the American Society for Testing Materials. The pamphlet is a reprint of the papers and discussions at a symposium on this subject held at a joint meeting of the American Society for Testing Materials and the American Society of Mechanical Engineers.

The four papers deal with industrial applications, methods of testing, available data on the properties of non-ferrous metals. Each one is concisely presented. The principal methods of testing have been reviewed and the most recent developments outlined. The last two papers comprise a thorough presentation of the representative data on tensile, torsion, hardness, crushing, impact, flow, expansion and other properties of metals under various temperature conditions, the data being classified for such materials as cast and malleable iron, cast steel, wrought iron, carbon steels, ordinary structural alloy steels, and high alloy content and the "heat resisting" steels; and in the non-ferrous field, for copper, brasses, bronzes, cupro-nickel, nickel and nickel alloys, aluminum and aluminum alloys, and bearing metals. A feature of the reprint is the bibliography, which contains 216 references arranged in chronological order.

Copies may be had for a nominal sum from the American Society for Testing Materials, Philadelphia, Pa.

An illustrated safe practice pamphlet dealing with "Teaching Safety to New Employees," has just been published by the National Safety Council. The pamphlet is non-technical in reading matter and is the combined experience of the industrial members of the Council. "Accidents to new employees," the pamphlet states, "are due not so much to carelessness or thoughtlessness as to lack of familiarity with the hazards and working conditions. Another factor is nervousness due to a desire to equal the production or speed of the more experienced workmen. Mechanical safeguards in specific industries may, to a certain extent, prevent accidents from both of those causes. The greater number of accidents, however, occur from causes that are not preventable by guards. Education and supervision are the only effective methods of attack for such accidents." The experience of the National Safety Council shows that it is advisable to reach the new man just as soon after his employment as possible. Inquiries regarding his pamphlet should be addressed to the National Safety Council, 168 North Michigan Avenue, Chicago.

Results of a study of coal-washing problems of the Pacific Northwest, made by the Department of the Interior in co-operation with the University of Washington, are contained in Bulletin 28, just issued by the engineering experiment station of that university at Seattle. The object of this investigative work, which was conducted at the Northwest experiment station of the Bureau of Mines, Seattle, Washington, was to devise coal-washing methods which would prevent loss of good coal and render dirty coals suitable for commercial purposes by effectively and economically removing the impurities.

Catalog Notes

"Holophane Helps to Make Well Known Quality Products" is the name of a book recently issued by the Holophane Company. This 20-page book describes specific industrial lighting units, their use and application to special industry. Photographs of several outstanding installations with data on each is included.

Two interesting bulletins have just been issued by the Hardinge Co., of York, Pa., one of which, entitled "Fine Grinding with Tube Mills," illustrates and describes the conical tube mill and the other, entitled "Grinding and Mixing with Batch Mills," deals with the application and principle of the cylindrical and Hardinge conical batch mills.

Catalog No. 30 is now being distributed by the Chicago Fuse Mfg. Co. It contains a complete listing of the electrical protecting materials and conduit fittings as manufactured by that company. In this revised catalog a special effort has been made to simplify listings and to give such information as will assist in the selection of materials best serving their respective purposes.

Bulletin No. 47,640.2, devoted to induction, time, over-current relays, types IA-201, IA-202, IA-205 and IA-206, has been issued by the General Electric Co. It describes the four forms of over-current relays, together with the applications of each. Details of construction, lists of available ratings and principles of operation are covered, together with other general information. The bulletin is illustrated by photographs, charts and diagrams and contains 15 pages.

The Goulds Manufacturing Co., Seneca Falls, New York, has recently issued a pamphlet entitled "Investigation of the Performance of Centrifugal Pumps When Pumping Oil," which is a report prepared by Robert L. Daugherty of the California Institute of Technology and describes an investigation to determine the adaptability of centrifugal pumps for this service. Various charts are given to show the performance of centrifugal pumps when handling oils of various viscosities as compared with the performance when handling water.

"Design and Control of Concrete Mixtures" is the title of a pamphlet recently issued by the Portland Cement Association, which deals with the factors that control the potential strength of concrete. The methods of design are illustrated with several typical examples and accepted standard methods for determining the suitability of aggregates have also been included. The pamphlet contains articles dealing with water ratio theory, factors in the design of concrete mixtures, design and control of concrete mixtures with field equipment, testing the concrete, typical examples and standard specifications and tests for concrete and concrete aggregates.

Specifications for Architects and Engineers is the title of a six-page specification sheet just published by the CoKal Stoker Corporation of Chicago. This has been specially prepared to give complete information to architects, consulting engineers and others concerned with specifying and installing semi-mechanical stokers under boilers. The most desirable settings for smokelessness and high combustion efficiency are given for nine different types of boilers. There is also a table giving the various dimen-

sions of the furnace and boiler settings for the various boiler arrangements. A table of chimney capacities gives both diameter and height for capacities ranging from 23 to 6155 b.hp., for diameters ranging from 18 to 144 in., and for heights from 50 to 300 ft.

"Refractories and Furnace Design, Second Edition," is the title of a booklet just issued by the Plibrico Jointless Firebrick Co., of Chicago, Ill. This booklet takes the form of a treatise on the building of monolithic furnace linings with Plibrico furnace lining. Considerable space is devoted to the proper installation of linings, telling how they should be installed to insure long life. Other sections describe the use of this lining for furnace fronts, arches, side walls and bridge walls in boiler furnaces and for heating furnaces.

Opening of oil switches and disconnecting switches in proper sequence, avoidance of opening disconnect switches when carrying load and provision against contact with live instrument transformers or other apparatus in bus and feeder cells are essential in preventing accidents to equipment and operatives. Bulletin No. 105-29-B, sent by Chas. Cory & Son, Inc., of 187 Varick St., New York, on request, gives the details of many types of Cory Robinson interlocks which are designed to accomplish these results and shows typical methods of installation.

The Nuway Boiler and Engineering Co., Chicago, has issued an interesting eight-page treatise dealing with the principles of boiler circulation. This treatise discusses the importance of rapid circulation of boiler water, together with reasons why rapid circulation is so important as a means of preventing priming, foaming and wet steam. The effect of smaller fire tubes, increased staggering and greater space between tubes upon the rate of flow is discussed; also the use of baffle and end plates in such a manner as make the water velocity higher than by uncontrolled convection.

The American Spiral Pipe Works, Chicago, Ill., has just issued its Catalog 24, which contains many tables which are new and hitherto unpublished. Some of these deal with forged steel flanges for high pressures, which have recently been standardized and the new standard facings, Sargol type of joints, boiler nozzles, seamless rolled steel rings and corrugated furnace tables. The book is well illustrated and arranged for the convenience of engineers in designing their pipe lines.

An informing discussion of apparatus for the production of distilled water for boiler feed make-up is presented in a 32-page catalog distributed by the Wheeler Condenser & Engineering Co., of Carteret, N. J. The fitting of evaporators into power plant heat balance and the relation of the evaporator to other heat balance equipment is discussed, and various types of hookups are illustrated by the heat balance diagrams of representative stations, such as the Delaware Station of the Philadelphia Electric Corp., the Hales Bar Station of the Tennessee Electric Power Co., and the Seal Beach Station of the Los Angeles Gas & Electric Corp. The operating characteristics of four types of evaporators are described, two of which are film evaporators in which evaporation takes place from a falling film of liquid produced by showering the water over the tube nest, and two are submerged tube evaporators. A film type evaporator in which the evaporating surface is composed of return bend tubes is provided for large multiple effect, low or medium pressure installations; while for smaller installations the Ellipticoil film evaporator in which, to facilitate scale cracking, the tubes are shaped like two joined Bourdon gage tubes, is available. An evaporator with Ellipticoil tubes and similar to the Ellipticoil film type evaporator except that the tubes are submerged, is also for use in low and medium pressure installations, where submerged tube operation is desirable. For very high pressure installations, there is the Wheeler Contraflo submerged-tube evaporator. Other topics of interest are the advantages of distilled boiler feed water and the relative economy of multiple effect operation as affected by the number of effects and the direction of liquid flow.

The Century Electric Co., of St. Louis, Mo., announces in a folder its new repulsion start induction motors, which are applicable to such uses as home refrigerating machines, oil burners, house pumps, ice cream cabinets, etc.

The Bridgeport Brass Co., Bridgeport, Conn., has just issued the Bridgeport Data Book No. 12, which contains tables giving the prices and weights of sheet brass, brass rod, wire, condenser tubes and seamless brass and copper tubes.

"Putting It to the Test" is the title of a folder, which is being distributed by the Standard Conveyor Co., of North St. Paul, Minn. This pamphlet describes the Standard Tiering Machine, which is essentially a portable elevator and has many uses about an industrial plant.

American Cast-Iron Storage Tanks are described in a recent pamphlet published by the Conveyors Corporation of America, Chicago. These tanks are sectional and can be easily and quickly erected without expert labor. The pamphlet shows a number of installation views.

The Martindale Electric Co., Cleveland, Ohio, has just issued a catalog under the heading "Motor Maintenance Equipment," describing the various tools which this company manufacturers for men in charge of motor maintenance.

Skip Hoists and their application are treated in a book just issued by the Link-Belt Co. of Chicago, Illinois, which explains the function of the skip hoist and its relation to other types of mechanical equipment, tells where and on what classes of work these hoists are profitably used, gives details of operation, capacity, design and construction.

The Vacuum Ash & Soot Conveyor Co., Newark, N. J., has just issued a catalog describing the Vasco system of conveying ashes and the features of the various fittings which are used in the system. The catalog contains a number of views showing how the system is installed and being used in power plants of various kinds.

Trico Fuse Manufacturing Co., of Milwaukee, Wis., announces a new line of non-renewable cartridge fuses, which are built in all standard sizes up to 600 amp. for both 250 and 600 v. and will be marketed under the trade name of "Kantark." These new fuses are described in catalogs recently issued by the company.

The Falk-Bibby Flexible Coupling is described in Bulletin 35 recently issued by the Falk Corporation, Milwaukee, Wis. The Bulletin describes by both words and pictures the construction of this flexible coupling, which is built in sizes suitable for connecting shafting where the load range is anywhere between ⅓ and 20,000 hp. and the speed 100 r.p.m.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Tuning Up with the Season!

Nature's power plant is going through its annual overhauling and her countless processes are speeding up to full production.

Rivers of sap are flowing through millions of miles of tiny pipes in roots and stalks, trunks and twigs.

Earth-drawn materials rise to become visible in tender greens that sweep over plains and hills as though painted with a mighty brush.

Man and all his works can neither stop nor stay this process but, working with it, he can control it to his purposes.

His the choice as to whether the fields shall be clothed with the verdure of grain or of weeds.

In like manner, the minds of men have their cycles of dormancy and revivification.

"Cultivating" the mind is so apt a simile that it has become a universal expression.

In this process words are the seeds, thoughts and ideas their germination and growth and deeds the harvest in its season.

Mind cultivation is now recognized to be the master process of all processes. As it has extended from class to mass, improved its methods and broadened its scope, its power over every field of human endeavor and of all material resources of the world has become more directly controlling.

The seed of words has grown into deliberate and planned improvements in methods of agriculture that have mastered Nature so that millions of people live in plenty where a few thousands existed precariously when dependent on natural food supplies.

In the power plant field a similar process has multiplied horsepower and brought it to the infinite services of our hands and eyes.

Indeed for all men in all industries and in the most remote fields subsidiary to industry, mind cultivation is being transformed by power plant men into lifting and carrying, grinding and finishing, heating and cooling—into processes indispensable to every product known to man.

In mind cultivation itself, mechanical power is the master factor in the multiplication of words, for it alone has reduced the cost and increased the speed of their distribution by making modern publications possible.

Multiplication of words is as essential to mind cultivation as is the broadcasting of seeds to secure a stand of grain. Prepare the soil as you will, sow under the most favorable conditions, yet many seeds must be sown for each plant that is grown.

Civilization, dependent on co-operation, increases the interdependence of all men and advances only with the unification of thought.

Consensus of opinion, accepted practice, standardized methods, are the great dynamic forces that bring health, wealth and happiness.

Looking to the future we can see in the fields of power, of agriculture, and in every other field, possibilities of advancement greater than all the progress made by man from the stone age to the present day.

It is a universal law that use and application vastly increase discoveries and theoretical improvements, but these, in turn, must be tried, perfected and accepted before progress is made.

Broadcasting information, hastening the formulation of opinion, the acceptance of standards and setting higher ones is the mind cultivation that is the most powerful, controlling and wealth-increasing force in the world.

Now is the season of overhauling in the power plant, in a year of rapid advance in the application of better methods for power generation and in an era of unprecedented increase in the demand for power from a world awakening to a universal insistence upon the freer and more abundant life which power alone can make possible to mankind.

Undoubtedly the harvest will be reaped. Without question the fields will produce. What each man's field shall bear and whether it be much or little depends on the sowing and cultivation of today.

This magazine can only be the medium which bears the seed. Though that seed has been most carefully selected from known and tested plants, winnowed and stored and passed on with the utmost of care, still it is only the seed.

Yours to take it, use it, cultivate it, and yours, too, the harvest of many fold.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR CHAMBERS.
Hercules Float Wks., Springfield, Mass.

AIR COMPRESSORS.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
American Steam Pump Co., Battle Creek, Mich.
American Well Works, The, Aurora, Ill.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.
Murray Iron Works Co., Burlington, Iowa
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros. Co., Chicago, Ill.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Cooling Tower Co., Inc., The, New York.

ALARMS, HIGH AND LOW WATER
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio

ARCHES, BOILER AND COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Lavino & Co., E. J. Philadelphia.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.

ASH CONVEYING SYSTEMS.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Conveyors Corp. of America, Chicago, Ill.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Link-Belt Company, Chicago.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyors Corp., Chicago, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
United Conveyors Corp., Chicago, Ill.

ASH TANKS.
United Conveyors Corp., Chicago,

BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.

BEARING METAL.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

BEARINGS.
National Tube Co., Pittsburgh.

BELT CONVEYORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Stearns Conveyor Co., The, Cleveland, Ohio.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.
Weller Mfg. Co., Chicago, Ill.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co., (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury,
Flexible Steel Lacing Co., Chicago.

BELTING.
New York Belting & P'k'g. Co., New York.
Pioneer Rubber Mills, San Francisco.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.
Voorhees Rubber Mfg. Co., Jersey City, N. J.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE.
Carling Turbine Blower Co., Worcester, Mass.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J. Philadelphia.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 164

Terry Steam Turbine Co., Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT.
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, PORTABLE
Sturtevant Co., B. F., Hyde Park, Mass.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.
Sherwood Mfg. Co., Buffalo, N. Y.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Carling Turbine Blower Co., Worcester, Mass.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
King Refractories Co., Inc., Buffalo, N. Y.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Specialties Co., Inc., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUND.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chemical Co., Inc., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER FEED WATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chemical Co., Inc., New York.
Permutit Co., New York, N. Y.
Power Plant Specialty Co., Chicago, Ill.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J. Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Murray Iron Works Co., Burlington, Iowa
National Tube Co., Pittsburgh.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., N. Y.
Badenhausen Corporation, Philadelphia, Pa.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Casey-Hedges Co., The, Chattanooga, Tenn.
Edge Moor Iron Co., Edge Moor,
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa
Union Iron Wks., Erie, Pa.
Vilter Mfg. Co., Milwaukee, Wis.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., Saginaw,

BOOKS AND SCHOOLS.
McGraw-Hill Book Co., Inc., New York, N. Y.
Sweet's Catalogue Service, Inc., New York, N. Y.

BREECHINGS.
Littleford Bros., Cincinnati, O.

BRICKS, FURNACE LINING.
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO AND MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.
Link-Belt Company, Chicago.
Webster Mfg. Co., The, Chicago.

BUCKETS, CLAMSHELL.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.

CAR DUMPERS.
Wellman - Seaver - Morgan Co., The, Cleveland, O.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry. Inc., Troy, N. Y.

CEMENT, ASBESTOS.
New York Belting & P'k'g. Co., New York.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh.
King Refractories Co., Inc., Buffalo.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Plibrico Jointless Firebrick Co., Chicago.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
King Refractories Co., Inc., Buffalo, N. Y.
Lavino & Co., E. J. Philadelphia.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Obermayer Co., The S., Chicago.
Plibrico Jointless Firebrick Co., Chicago.
Quigley Furnace Specialties Co., Inc., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York.

CIRCUIT BREAKERS.
Cutter Co., The, Philadelphia.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo.
Roto Co., The, Hartford, Conn.
Sherwood Mfg. Co., Buffalo, N. Y.

CLEANING COMPOUND.
Dearborn Chemical Co., Chicago, Ill.

COAL AND ASH-HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Brown Hoisting Machinery Co., The, Cleveland, Ohio.